Ministry of the Environment
Ontario

PART E
ENVIRONMENTAL ECONOMICS

NOVEMBER 30 &
DECEMBER 1, 1987

ROYAL YORK HOTEL
TORONTO, ONTARIO, CANADA

PROCEEDINGS

TECHNOLOGY TRANSFER CONFERENCE

NOVEMBER 30 - DECEMBER 1, 1987

ROYAL YORK HOTEL

PART E

ENVIRONMENTAL ECONOMICS

Organized through the

RESEARCH ADVISORY COMMITTEE

Sponsored by

ENVIRONMENT ONTARIO

Ontario, Canada

99

INTRODUCTION

Environment Ontario holds its annual Technology Transfer Conference to report and publicize the progress made on Ministry-funded projects. These studies are carried out in Ontario universities and by private research organizations and companies.

The papers presented at the 1987 Technology Transfer Conference are included in five volumes of Conference Proceedings corresponding to the following sessions:

Part A:	Air Quality Research
Part B:	Water Quality Research
Part C:	Liquid & Solid Waste Research
Part D:	Analytical Methods
Part E:	Environmental Economics.

This part is a compilation of papers presented during Session E of the Conference.

For further information on any of the papers, the reader is kindly referred to the authors of to the Research Management Office at (416) 323-4574, 332-4573.

ACKNOWLEDGMENTS

The Conference Committee would like to thank the authors for their valuable contributions to environmental research in Ontario.

SESSION E: ENVIRONMENTAL ECONOMICS

E1 **UTILIZATION OF COTTAGERS' PERCEPTIONS IN ASSESSING THE PRESENCE AND IMPACT OF ALGAE ON ONTARIO RECREATIONAL LAKES.**
K. Neuman, M.B. Jackson and K.H. Nicholls, Environment Ontario, Toronto, Ontario.

E2 **REGULATION AS A CAUSE OF POLLUTION REDUCTION: TWO CASE STUDIES.**
D.N. Dewees, Department of Economics, University of Toronto, Toronto, Ontario.

E3 **FINANCIAL ASSURANCE - A NEW TOOL FOR ENVIRONMENTAL PROTECTION.**
J. A. Donnan, M.B. Jackson and J. Swaigen, Environment Ontario, Toronto, Ontario.

E4 **DISPOSAL OF FORMATION FLUIDS BY OIL PRODUCERS IN PETROLIA, ONTARIO - AN ENVIRONMENTAL-ECONOMIC ASSESSMENT.**
M. Goodchild, Department of Geography, University of Western Cntario, London, Ontario, and J. A. Donnan, Environment Ontario, Toronto, Ontario.

E5 **BEACHES IN LOTUS: A MICROCOMPUTER MODEL OF SPATIAL RECREATION BEHAVIOUR**
J. B. Ellis, Department of Environmental Studies, York University, Toronto, Ontario.

E6 **THE TRANSPORTATION OF LIQUID INDUSTRIAL HAZARDOUS WASTE IN ONTARIO.**
A. Donner, N. Mogil and R. Thompson,
ARA Consultants, Toronto, Ontario.

EP1 **THE EFFECTS OF FORESTRY OPERATIONS UPON THE ENVIRONMENT OF ONTARIO.**
J. Dunster, Federation of Ontario Naturalists,
Don Mills, Ontario.

EP2 **BIOTECHNOLOGY POLICY DEVELOPMENT.**
Canadian Environmental Law Research
Foundation, Toronto, Ontario.

UTILIZATION OF COTTAGERS' PERCEPTIONS
IN
ASSESSING THE PRESENCE AND IMPACT OF ALGAE
ON
ONTARIO RECREATIONAL LAKES

Keith Neuman, Michael B. Jackson and K.H. Nicholls,
Ontario Ministry of the Environment,
Toronto, Ontario

ABSTRACT

Based on recent evidence suggesting that the growth of two types of algae--filamentous (e.g., Zygnema spp.) and odour-producing (i.e., Chrysochromulina)--in Ontario softwater lakes may be the result of increasing acidification, the Ministry of the Environment conducted a study to obtain an accurate assessment of the incidence of these algae and their impact on lake recreational uses. Because the cost of conventional field surveys was prohibitive, an innovative approach was utilized which tapped the perceptions and first-hand experiences of lakefront cottage owners. A pilot study conducted on 10 lakes demonstrated that by using a multivariate predictive model, cottagers' perceptions could be used to accurately identify algae conditions on lakes. The main study produced data from a statistically representative sample of 4,400 cottagers on 214 lakes in central Ontario. Results indicate that filamentous algae are present in approximately 48% of lakes in the area, and odour-producing algae are present in about 6% of these lakes. A statistically significant positive relationship was observed between algal presence and lake acid sensitivity. Cottagers experiencing algae on their lakes expressed a high level of concern about algae growth and indicated that it has affected their general enjoyment and specific uses, such as swimming and boating. It is concluded that this type of social science research approach has potential applicability to the study of other environmental conditions.

INTRODUCTION

Recent evidence suggests that the growth of two types of lake algae has been increasing over the past several years in softwater lakes in central Ontario. These types of alga, a cloud-forming filamentous alga (e.g., Zygnema spp.) and a planktonic, odour-producing alga (i.e., Chrysochromulina breviturrita), may be spreading in part as a

result of the acidification of lakes in this area. Both types of algae can interfere with recreational use and enjoyment of lakes. Mass development of filamentous algae can clog shorelines and inhibit recreational activity (Jackson, 1985), while the Chrysochromulina species at times produces a distinctly unpleasant, cabbage-like odour (Nicholls et al., 1982).

The potential impact of significant algae growth on lake water quality and recreation is considerable. Laboratory and field studies have focussed on determining the causes of algae growth, but there is limited information, beyond anecdotal accounts, on the extent of such growth in Ontario lakes and its impact on human activity. As a first step in addressing this issue, the Ontario Ministry of the Environment, under its acid precipitation and inland lakes programs, undertook a study for the purpose of: a) obtaining an accurate estimate of the incidence of algae growth (filamentous, odour-producing) in central Ontario lakes; and b) identifying the extent to which such algae growth is seen to be a problem by lakefront property owners and has affected their use of the lakes and their property.

Field surveys, the conventional method by which data on environmental conditions are collected, was not suitable for meeting these study objectives, primarily because the cost of this approach would be prohibitive given the large number of lakes that must be surveyed in order for the results to be generalizable to the region. In addition, traditional field assessment techniques are not capable of gathering information on non-observable human impacts of algae, such as cottagers' perceptions of algae and how they affect recreational enjoyment.

Instead, an innovative approach was employed which assessed algae conditions and their impacts by tapping the perceptions and first-hand experiences of lakefront cottage owners. This

represents a new approach to gathering environmental data on a large scale, yet it is also consistent with an established tradition in Ontario in which local citizens have played an active role in assisting the Ministry of the Environment with its environmental studies. An outside consultant, SPR Associates Incorporated, was hired to design and carry out the study, under the direction of Ministry water quality and social scientists.[1]

METHODS

The use of cottager reports to assess algae conditions and their impacts rests on several assumptions: a) that cottagers are capable of accurately identifying and reporting the presence of algae; b) that the consensus of cottager reports of algae on a given lake will provide an accurate indication of the presence of algae in that lake, regardless of inaccurate reporting by specific cottagers; and c) that cottagers are the best source of information on how algae have affected their use and enjoyment of their lakes.

The primary methodological issue to be addressed in this study was the validity or accuracy of cottagers' reports. No previous studies have been done on algae or other environmental phenomena which provide a clear indication of how accurate such reports might be. Stokes (1982) conducted an informal survey of cottagers, anglers and resort owners about algae conditions, but did not assess the validity of the responses obtained. The literature in psychology indicates that in general people can be accurate in their reports of recent events, but are also subject to biases in their memory, perception and/or reporting of such events, depending on the characteristics of the event, the individual and the way in which the survey questions are framed (Schuman and Presser, 1981; Warwick and Lininger, 1975). Such biases can to some extent be minimized through the use of established survey research techniques.

Pilot Study. A pilot study was undertaken to assess the accuracy with which cottagers could report lake algae conditions and also to pre-test the survey procedures. Ten lakes were selected for which the Ministry has documentation of either the presence or absence of both types of algae. A self-administered questionnaire was delivered to approximately 250 cottages located on these lakes during the summer of 1985.

The questionnaire included a variety of a questions pertaining to filamentous and odour algae (e.g., whether the algae have been noticed this year, in which months, in which previous years, in what locations in the lake, how noticeable it has been and their impact on lake use and enjoyment), other lake phenomena affecting environmental quality (e.g., brown water, fishy odours) and cottagers' familiarity and use of the lake (e.g., number of years at lake, types of recreational activity). To maximize accurate reporting of filamentous algae, the questionnaire included a colour photograph of the algae in its most common form (gray-green cloud-like formations close to the surface near the shore). Because the odour-producing algae are microscopic and invisible to the naked eye, this species was described by its distinctive odour, "similar to that of cooking cabbage or a very 'ripe' compost heap."

Analysis of the pilot study data involved the development of a multivariate predictive model for each algae type to test the validity of cottager reports. These models included a number of the survey questions, based on the assumption that cottagers' responses to a range of questions about algae and other lake conditions would provide a more accurate prediction of actual algae presence than a single question asking whether or not it has been noticed. These models were tested using discriminant analysis, a multivariate statistical technique related to multiple regression in which cottagers or lakes were classified into mutually exclusive

groups (algae, no algae) based on the optimal linear function of the questions contained in the models.

The filamentous and odour models included the primary question about algae presence ("have you noticed this type of algae on your lake?"), plus other questions about algae (colour, location in the lake, time of year noticed, and how noticeable they have been). An additional factor was included, labelled "lake misperception", to measure the extent to which cottagers are overly sensitive to, and therefore report, unpleasant lake phenomena, such as odours or green scum. This final factor measurably improved the accuracy of prediction, by adjusting for the tendency of some cottagers to overreport lake problems, including other algae phenomena.

Results demonstrated that these models could provide an accurate prediction of algae presence or absence. For filamentous algae, 70% of cottagers were correctly classified and, across all cottagers on a given lake, all 10 lakes were correctly classified as to algae presence. Results were similar for odour-producing algae: 69% of cottagers and 9 out of 10 lakes were correctly classified. Based on these results, it was concluded that cottagers could provide a reasonably accurate report of lake algae conditions through the use of multiple indicators and multivariate predictive models.

Main Study. The main study was undertaken in 1986 to fulfill the study objectives. A representative sample of 204 lakes was selected from the population of populated lakes (those with 10 or more cottages) in central Ontario, for which information was also available on acid sensitivity and other characteristics of water chemistry and lake morphometry. Up to 40 cottage properties were systematically sampled on each lake, based on provincial property assessment files, yielding a total sample of 5,200 cottagers.

A modified version of the questionnaire used in the pilot study was mailed to the cottagers home addresses in June of 1986, followed by a series of reminders (e.g., postcards, letters), in accordance with established survey research techniques for maximizing response.[2] Completed questionnaires were obtained from over 4,400 cottagers, yielding an impressive response rate of 83%. This level of response reflects the high level of interest which many cottagers take in the quality of their lakes.

The predictive models were "recalibrated" using a larger sample of 32 lakes for which documentation of filamentous algae conditions was available. Because the aim of this study was to correctly classify lakes rather than specific cottagers, the discriminant analysis was modified to generate an aggregate level classification of each lake, based on the reports of all cottagers on that lake. This involved using the averaged values across all cottagers on a given lake, rather than the individual values, as the basis for the analysis. The results provide a classification of lakes into algae or no algae groups. One advantage of this approach is that it does not require the application of the somewhat arbitrary criteria for deciding what percentage of cottagers must report algae to classify it as an algae lake. These new multivariate, aggregate level models correctly classified the filamentous algae status of 31 out of 32 lakes, and the odour algae status of all 10 lakes from the original pilot sample.

RESULTS

Incidence of Algae. Application of the multivariate predictive models to the full sample of 214 lakes (including the original 10 pilot study lakes) provided results on the incidence of algae, which were then used as estimates for the larger population of lakes. These results indicate that filamentous algae are present on 48% of populated lakes in the area covered, with 32% having "some" and 16% having "considerable" levels of algae (see Table 1). Incidence was greatest in the Muskoka District, with 54% of lakes containing algae (20% some, 34% considerable), and to a lesser extent in the Counties of Haliburton (46%) and Parry Sound (37%). Odour algae appear to be much less widespread, being present in only 6% of all lakes. Again, the Muskoka area has the highest incidence of odour-producing algae.

TABLE 1

Estimated Incidence of Algae Presence by District
(percentage of lakes with algae)

	FILAMENTOUS*			ODOUR
	Some	Considerable	TOTAL	Some
ALL AREAS	32%	16%	48%	6%
Muskoka	20%	34%	54%	12%
Haliburton	30	17	47	8
Parry Sound	32	6	38	5

* Presence of filamentous algae was broken down into two categories: "some" where 5 to 20% of the shoreline is affected, and "considerable" where more than 20% of the shoreline is affected.

Because this study was cross-sectional, it was not possible to accurately assess trends in the incidence of algae over time. The survey did query cottagers about whether they noticed algae in previous years. While such data are subject to biases in memory and cannot be verified, cottager reports do suggest there has been a steady increase in algae since 1981 (see Table 2).

TABLE 2

Reported Incidence of Algae By Year
(% of cottagers reporting algae as
"definitely present" in previous years, N = 4407)

Year	Filamentous	Odour
1985	25%	6%
1984	22	6
1983	16	5
1982	11	3
1981	9	2
1980 or earlier	10	3

Algae and Acid Sensitivity. Analyses were performed to assess the strength of the relationship between algae presence and lake acid sensitivity, which may be a contributing factor in the apparent increase in algae growth. Results indicate a statistically significant positive association between the presence of each type of algae and lake acid sensitivity (filamentous: $\chi^2(8) = 29.7$; odour $\chi^2(4) = 40.8$; $p < 001$). While in both cases the association is significant well beyond what would occur by chance, in neither case is the association a strong one. The correlation between algae presence and acid sensitivity (as measured by a contingency coefficient) is only .29 for filamentous and .33 for odour. This means that if one assumes a causal relationship between acidification and algae (which this study cannot confirm), lake acidity would account for only 10% of the variance in algae growth. These data provide preliminary evidence of a link between lake acid sensitivity and algae growth, but further research is required to more precisely examine the nature of this relationship.

Impacts of Algae

Virtually all cottagers reporting either type of algae on their lake (92%) expressed concern about its presence. A number of specific impacts resulting from algae were reported by a significant proportion of the sample. The most commonly reported impacts were reduced enjoyment of the lake, reduced aesthetic enjoyment of the lake and shore, reduced enjoyment of swimming activity and reduced fish population (See Table 3). The reported impacts on fish is somewhat unexpected since there is no direct evidence that these algae impact fish populations. It is conceivable, however, that filamentous algae could foul spawning and nursery areas of some fish species.

TABLE 3

Reported Impacts of Algae
(% of cottagers experiencing filamentous and odour algae reporting specific impacts)

Impact	Filamentous	Odour
Reduced overall enjoyment of lake	68%	74%
Reduced aesthetic enjoyment of lake and shore	74	64
Reduced enjoyment of swimming activity	68	71
Reduced fish population	69	57
Reduced enjoyment of boating	28	35
Affected health	12	20
Number of Cottagers	1,400	413

One possible explanation for the frequent reports of impacts on fish is that the presence of "declining fish population" as a response category may have suggested to respondents that algae is in fact a possible explanation for an experienced loss of fish. This type of unintentional prompting is always a potential source of bias with a closed question format (Schuman and Presser, 1981).

Cottagers' concern about algae in their lakes was examined in the context of other types of lake-related problems. Across all cottagers sampled, acid rain was most often cited as a serious problem on their lake (60%), followed by poor or declining lake water quality (49%) and dead fish or declining fish population (36%) (see Table 4). Algae, by comparison, was not so widely seen as a serious problem. Only 29% mentioned filamentous algae and 13% mentioned odour algae as

TABLE 4

Relative Seriousness of Lake Problems
(% of cottagers rating each problem as serious on their lake)

Lake Problem	All Cottagers	Cottagers Reporting Filamentous Algae	Cottagers Reporting Odour Algae
Acid rain affecting lake	60%	66%	59%
Poor or declining quality of lake water	49	58	62
dead fish or declining fish population	36	37	33
Too much recreational activity	33	27	25
Too much shoreline development	30	27	22
Filamentous algae	29	66	47
Poor or declining aesthetic appearance of lake and shoreline	23	25	21
Algae odour	13	17	52
Number of Cottagers	4,407	1,400	413

a serious problem. However, these numbers reflect in part the fact that only a minority of cottagers have experienced either type of algae on their lake. When the analysis is limited to those cottagers who have reported filamentous algae, its seriousness relative to other lake problems is considerably higher: filamentous algae, together with acid rain, are most frequently mentioned as a serious problem (see Table 4). Similarly, odour algae is among the most frequently cited problems by those reporting its presence on their lake. These results suggest that algae only becomes a problem when directly experienced, in contrast to more global problems such as acid rain, for which concern may not be based primarily on clearly observable impacts.

Results indicated that filamentous and odour algae clearly have an impact on cottagers' enjoyment and use of their lakes. To what extent do these impacts impair overall satisfaction with the lake experience? Multiple regression analysis was performed to assess the extent to which algae and other lake-related concerns predicted cottagers' overall level of satisfaction with their lake experience. The results indicate that a few concerns have a small but statistically significant impact on overall satisfaction, including concerns about: poor or declining water quality for swimming, recreation, drinking and cooking; filamentous and odour algae; and to a lesser extent aesthetic appearance of the lake and shoreline. None of these concerns are a strong predictor of satisfaction (with beta coefficients in the range of .1 to .6) and together they account for only 16% of the variance in satisfaction.

These data suggest that lake-related problems are important, but constitute only part of what determines cottagers' satisfaction with their lakes. Despite widespread mention of a number of lake-related problems and concerns, most cottagers sampled in this study (63%) were satisfied with their lake, while only 12% expressed clear dissatisfaction.

CONCLUSION

Several major conclusions can be drawn from this study. The results indicate that filamentous algae are widespread among the softwater lakes of central Ontario, and that the incidence of these algae is higher in acid sensitive lakes. While this study does not address the effect of acidification on filamentous algae growth, whole-lake experiments have shown that reducing lake acidity through liming essentially eliminates filamentous algae (Turner et al., in press), while increasing lake acidity through the addition of sulphuric acid greatly increases filamentous algae (Jackson et al., in

preparation). Ministry-funded studies are continuing to examine further the role of acidification and other controlling factors in algae growth.

The appearance of both filamentous and odour algae have a clear impact on recreational lakes. The results of this study do not suggest that algae are spoiling cottage vacations or scaring away potential visitors. But clearly these algae are a cause for concern for many cottagers, in terms of affecting aesthetic and recreational activities. Neither type of algae is yet a part of the experience of most cottagers, but the occurrence is not an isolated problem. The results of this study were described by the president of the Federation of Ontario Cottagers Associations as a "true reflection" of the concerns of her group's 40,000 members (Toronto Star, 1987). If the incidence of these algae should increase over the next several years, it can be expected to emerge as one of the major environmental issues across the region.

Another major conclusion of this study is that social science survey research techniques which tap public perceptions can be an effective and efficient means of gathering field information on certain types of environmental conditions. This approach will not replace conventional field survey methods, given the need for direct observation, collection of physical sampling and other requirements. Yet gathering environmental data through people's perceptions may have useful applications, particularly where other methods are too costly or where information about public views and responses is desirable. Such surveys may also be used as a complement to conventional field surveys, as a means of comparing residents' perceptions to actual conditions.

Further research needs to be done to refine the type of approach developed in this study and further explore its applicability. Public surveys may prove to be an important tool for measuring environmental conditions because people possess both a wealth of information and valuable perspectives that are often essential to fully understanding and addressing environmental problems.

NOTES

1 A more complete version of the research presented in this study can be found in Estimation of the Presence and Impact of Filamentous and Odour-Producing Algae: A Survey of Cottagers on 214 Ontario Recreational Lakes, SPR Associates Inc., December 1986. This report is available from the Ministry of the Environment, Communications Branch, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5.

2 Copies of the questionnaire can be obtained from the first author at the following address: Policy and Planning Branch, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5.

REFERENCES

JACKSON, M., E. VAN DER MEER, N. LESTER, J. BOOTH and L. MOLOT. Response of Filamentous Algae and Macrophytes to Lake Liming and Early Reacidification. Canadian Journal of Fisheries and Aquatic Sciences, in preparation.

JACKSON, M.B. Algae in Ontario Softwater Lakes. International Symposium on Acidic Precipitation, Muskoka, Canada, September 15-20, 1985. pp. 117-118 (abstract).

NICHOLLS, K.H., J.L. BEAVER and R.H. ESTABROOK. Lakewide Odours in Ontario and New Hampshire caused by Chrysochromulina breviturrita Niche. (P.rymnesiophyceae). Hydrobiologica, 96, 1982. pp. 91-95.

SCHUMAN, HOWARD and STANLEY PRESSER. Questions and answers in Attitude Surveys, Academic Press, New York, 1981.

STOKES, PAMELA. An Investigation of Periphyton Growth in Acid-stressed aquatic habitats. A Literature and Public Perception Survey. Final Report to the Ontario Ministry of Natural Resources, January 1982.

TORONTO STAR. "Ministry blames acid rain for cottage country slime", April 14, 1987, p. A12.

TURNER, M., M. JACKSON, D. FINDLAY, D. SCHINDLER, R. GRAHAM, E. DeBRUYN and L. VAN DER MEER. Responses of haptobenthos to experimental whole-lake additions of sulphuric acid and nitric acids. Canadian Journal of Fisheries and Aquatic Sciences, in press.

WARWICK, DONALD and CHARLES LININGER. The Sample Survey: Theory and Practice. McGraw-Hill, New York 1975.

Regulation as a Cause of Pollution Reduction:

Two Case Studies[1]

Preliminary Report

D.N. Dewees

October, 1987

For MOE Technology Transfer Conference

I. Introduction

This study explores changes over time, and the causes of these changes, in pollution discharge in Ontario since 1970. Two primary hypotheses are tested. The first hypothesis is that the adoption of quantitative discharge standards significantly affects the rate of pollution discharge. The second hypothesis is that enforcement efforts, including increases in the sanctions that may be applied, significantly affect those discharges. These hypotheses are tested by reviewing evidence regarding discharge rates and a number of variables that might affect these discharges. The variables include: the quantitative discharge limit; regulatory effort and penalties; tort liability; pressures brought to bear on the firm by workers or the public; changes in production inputs or outputs; and the prices of pollution related inputs or outputs.

I consider this question in the context of two case studies. The first, a study of mercury discharge from chlor-alkali plants, appears to represent a major success for regulatory agencies. Mercury discharges

---

[1] This research has been supported by the Sanctions and Rewards project of the University of Toronto Faculty of Law, funded by the Canadian Institute of Advanced Research, and by a grant from the SSHRCC. Steven Rigby provided invaluable research assistance.

were reduced 95 per cent in one year, and within three years were less than one per cent of their 1970 amount. The second case, in contrast to the first, appears to be a regulatory failure. Efforts have been made to limit sulphur oxide discharges for almost two decades, yet the reduction in discharge in Ontario between 1970 and 1986 amounts to only about 50 per cent. The study of the history of these cases reveals differences that tend to explain the different outcomes, and thus to illuminate those factors that contribute to effective regulation.

II. The Literature

A. General Effects of Environmental Regulation

Economists have generally been critical of government regulation of pollution discharge because of both its inefficiency, and its apparent ineffectiveness. While annual reports of the Council on Environmental Quality (C.E.Q. 1985) point to more than a decade of reductions in concentrations of a set of air and water pollutants, outside observers have often expressed dissatisfaction with this progress. Anderson et al (1977, p. 148) Baumol and Oates (1979, p. 335), and Tietenberg (1985) suggest that environmental regulation in the United States has slowed the increase in pollution discharge since 1970, and in some cases reduced it, but has not achieved large reductions in emissions except in a few cases. A similar pattern seems to emerge from the available Ontario data. Data on discharges of airborne pollutants show modest declines in general since 1970, with somewhat more modest improvements in ambient air quality at the predominantly urban monitoring stations. Table 1 shows average ambient quality improving, but some of the reported decline in pollution

levels is a consequence of the great increase in the number of sampling stations, many of the additions being in rural or low pollution locations. Water pollution discharges have similarly declined modestly in many cases, with a few increases, and a few dramatic reductions.[2]

Even this limited success may not be attributable entirely to agency regulatory action. Mills and Graves (1986) attribute these successes to a few simplistic sources: the construction of sewage treatment plants for municipal sewage disposal, and the substitution of clean oil or gas for dirtier coal as a fuel. These trends were occurring even before the environmental legislation of the 1970's, and may have been only modestly accelerated by regulations (Mills and Graves, 1986, p. 251). Commoner (1987) shares this pessimistic view of environmental trends since 1970, asserting that the limited successes that have been achieved result from cessation of the use of the polluting material. Thus concentrations of lead in the air are greatly reduced because lead has been phased out of gasoline. DDT in the environment has dropped dramatically because its use has been banned, just as the halt in above ground nuclear testing lead to a dramatic reduction in Strontium 90 in the environment.

B. **Industry/Pollutant-Specific Studies**

There are few studies by economists of the effect of regulation on the discharge of specific pollutants or the discharge of pollution from specific industries.[3] One recent study by Magat and Viscusi (1987) explores the effectiveness of U.S. federal water pollution regulations in reducing the pollution discharge of the pulp and paper industry.

---

[2] Ontario Statistics, various years, Table 33.1 et seq.

[3] See Crandall (1983) for a review of the existing literature.

Analyzing quarterly data on 77 separate plants from 1982 to 1985, the authors find that inspections by the EPA have a statistically significant effect on pollution discharge levels, on the rate of violation of applicable discharge standards, and on the regularity of filing of required discharge monitoring reports. The effect of an inspection, moreover, persists. The results suggest than every inspection causes a once and for all reduction in total pollution discharge of about 20 percent, a substantial reduction. This reduction occurs with a lag of one quarter of a year; no further effect of the inspection occurs in subsequent quarters. This study suggests that environmental regulation, in contrast to occupational safety regulation, is relatively effective, in part because environmental inspections, in large plants, are much more frequent than are occupational health and safety inspections. The authors also note that success is promoted by adopting realistic and feasible standards, in contrast with the often stringent standards applied in occupational safety.

III. THE MODEL

I assume that firms maximize profits, and will therefore spend resources to reduce pollution dischages only to the extent that this reduction is profitable for them. This implies that altruism or genuine concern for the state of the environment will be ignored. While in some cases more benevolent motivations may be demonstrated, the profit maximizing motivation seems likely to explain the majority of cases. Three principal forces generate incentives for firms to reduce pollution discharge. The first is the cost associated with violating government

regulations. If a quantitative discharge limit is exceeded, or if a general prohibition against harming the environment is violated, and if enforcement efforts are undertaken, then costs may be imposed on the firm. The most obvious such cost is the amount of any fine levied upon the firm for its offense. However until the 1980's, the amounts of such fines for environmental offences were almost invariably trivial.[4] That these explicit penalties are often small, however, does not mean that enforcement is without effect. The Ontario Ministry of the Environment may order the firm to reduce its discharge when that discharge is unlawful[5], and may even order the firm to cease discharge altogether in the rare event that there is an <u>immediate</u> danger to human life or health, or to property[6]. More commonly, the Ministry enters into a voluntary agreement called a program approval in which the firm agrees to a set of measures designed to reduce its discharge over time[7]. An agency may use violations in one area as an excuse to hold up approvals for new construction or plant modification in another area. In the face of a determined agency, firms will place a substantial value on maintaining satisfactory relations with the agency. This suggests that explicit

---

[4] In the United States, fines imposed by the EPA jumped dramatically in 1984 when the agency acquired the right to collect an amount equal to the profit from non-compliance with a regulation (Wasserman, 1987, p. 32.) In Ontario, the pulp and paper industry, while often not in compliance with water pollution standards, paid fines totalling less than $15,000 between 1968 and 1976 (Donnan and Victor, 1976.) More recently, maximum fines in Ontario have been raised to the level of $50,000 or $100,000 per count, and fines actually levied have increased greatly over those of the 1970's.

[5] <u>Environmental Protection Act</u>, R.S.O. 1980, c. 141, s. 6.

[6] <u>Environmental Protection Act</u>, s. 7.

[7] <u>Environmental Protection Act</u>, ss. 9, 10.

fines may vastly underestimate the incentive effects that the agency may be able to exert on the firm.

The second factor inducing firms to reduce pollution discharge is potential liability for any harm that might result from those discharges. In Ontario, individuals may exercise common-law rights based upon doctrines of riparian rights and private nuisance to recover damages for environmental harm, and in some cases to secure an injunction against further harmful discharge. The likelihood of success in such lawsuits and the size of possible recoveries would determine the magnitude of the incentive to control emissions.

A third factor is the polluter's concern about its public image. Large corporations that sell goods to the general public may wish not to have their name associated with what appears to be socially irresponsible behaviour. Such firms may be willing to spend substantial sums to avoid adverse publicity arising from conviction for pollution violations. On the other hand, firms that do not sell to the public may be much less concerned about public opinion, and worry less about the publicity associated with prosecution so long as their customers or clients have not expressed strong feelings on the matter.

A fourth factor may be changes in regulations in the United States. Multinational firms headquartered in the US may have a policy of applying local regulations or US regulations, whichever is most stringent. In such cases, reductions in the discharges allowed in the US should reduce discharges by Canadian subsidiaries.

Finally, changes in the state of scientific evidence may lead to changes in emissions. The development of proof that a discharge causes serious harm may strengthen the will of the regulatory agency, leading to more vigorous enforcement of regulations. It may also increase the likelihood of private tort lawsuits or adverse public opinion. Indeed, for the firm that is motivated by a desire to be a responsible citizen, such evidence may lead to improved controls without the explicit operation of the other factors listed above.

IV. Mercury from Chlor-Alkali Plants: Rapid Success

A. Introduction

The pulp and paper industry consumes large quantities of chlorine which is produced in Ontario and elsewhere in Canada in chlor-alkali plants which produce caustic soda as a joint product. In 1970, fifteen chlor-alkali plants, seven of them in Ontario,[8] used the mercury cell process, which competed at that time with the diaphragm cell process. In 1970, the fifteen Canadian plants discharged 67 thousand kilograms of mercury in their liquid effluents. While this mercury discharge was originally thought to be harmless, by 1965 a Swedish scientist reported that inorganic mercury of the kind used in chlor-alkali plants could be converted to methyl mercury in oxygen free surroundings such as muddy lake bottoms (Troyer, 1977, p. 25).

In February of 1969, a University of Western Ontario graduate student, Norvald Fimreite, announced the discovery of mercury

---

[8] Dow had two adjacent plants in Sarnia. If these are counted as one plant, then there were 14 in Canada, 6 in Ontario.

contamination in fish from Lake St. Clair. As a result of this discovery, the Ontario Water Resources Commission performed analyses which revealed traces of mercury in soil samples taken from Lake St. Clair. A series of events followed which reduced the discharge of the Canadian chlor-alkali plants from 67,000 kilograms in 1970 to 3,000 kilograms in 1971, and to approximately 500 kilograms by 1973. In a three year period, the discharge of this pollutant was reduced to less than 1 per cent of its original amount. See Tables 2, 3. Discharges were reduced still further over the succeeding years. This almost complete elimination of mercury from the discharge was achieved in the first instance by recycling liquids within the plant, by treating mercury contaminated solids in sludges in temporary holding ponds, and by finding substitutes for water flows for cooling mercury liquid and vapors. Further reductions were achieved by installing equipment for the removal of mercury from electrolitic cell brine effluents. (Flewelling, 1975) Over the years after 1970 the mercury process plants closed and were replaced by diaphragm cells, until few mercury plants remain today. Most of the reduction in mercury discharge was achieved however by controlling existing mercury plants.

B. Regulation

Both federal and provincial environmental agencies take substantial credit for the dramatic reduction in mercury discharge.

> "In 1970-71 all mercury cell chlor-alkali plants through working agreements with federal and provincial governments, altered their operating practices to separate contaminated waste waters from relatively clean waste waters, recycle as much of the contaminated waste water as practical, and treat the remainder. These measures, combined with plant closures and conversion to non-mercury cell processes, have reduced

> mercury discharges in liquid effluents by more than 99 per cent." (EPS, 1985, p. 1)

Several legislative bases for such action existed. Until June, 1970, the Fisheries Act provided that "No person shall...put...chemical substances...or any other deleterious substance...in any water frequented by fish."[9] The penalty for violating section 33(2) was a maximum fine of $1000 or six months in jail for a first offence, and a fine of $2000 or 12 months in jail for subsequent offences. By amendment assented to on June 26, 1970, section 33(2) was altered to read: "...no person shall deposit...a deleterious substance of any type in any water frequented by fish", and a definition of deleterious was added in section 33(11): "deleterious substance means...any substance that, if added to water would degrade...that water so that it is rendered deleterious to fish or to the use by man of fish that frequent that water".[10] Under this language the mercury discharge which rendered the fish dangerous to man would clearly violate the act, a point that was previously in doubt, while at the same time the risk that the section might be ultra vires because it reaches beyond the fisheries power is eliminated. The same amendment increased the penalties to $5000 for each offense, with each day constituting a separate offense. In December 1970, the federal environment minister asked the industry to control mercury losses voluntarily, and in February 1971 the government announced its intention to limit mercury discharge to .005 pounds per ton of chlorine produced. On April 1, 1971 a guideline of .01 pounds per ton of chlorine was

---

[9] Fisheries Act, R.S.C. 1970, c. F-14, s. 33(2).

[10] Fisheries Act. R.S.C. 1970 (1st Supp.), c.17.

endorsed by the federal government, a limit which dropped to .005 pounds per ton in September of 1971. The role of these guidelines, in the absence of enforceable regulations, was presumably to indicate emission reductions that would not lead to prosecution under section 33(2). In March 1972, the Chlor-Alkali Mercury Regulations were introduced, to become effective in June of 1972.[11] These regulations incorporated the .005 pound per ton discharge limit. No charges were laid under the federal Fisheries Act until 1976.

Provincial legislation was also relevant to this discharge. Section 32 of the Ontario Water Resources Commission Act (OWRCA)[12] prohibited the discharge of material into a river that may impair the quality of the water. Each day was a separate offence and the penalty was $5,000 for first offence and $10,000 and/or a year imprisonment for each subsequent offence. The OWRCA also provided for a closure order, although such orders were not widely used.[13]

In the summer of 1969, the Ontario Water Resources Commission (OWRC) having confirmed high concentrations of mercury in sediments from Lake St. Clair notified Dow Canada of these findings downstream from its Sarnia plant. High concentrations of mercury in fish were reported in January and March of 1970. When Fimreite informed the Canadian Wildlife Service of his fish contamination findings, the federal Fisheries Department prohibited fishing on Lake St. Clair and the Detroit, St. Clair, and Wabigoon Rivers for the 1970 fishing season, beginning late in

---

[11] Chlor-Alkali Mercury Regulations, SOR/72-92.

[12] R.S.O. 1970, c. 332.

[13] R.S.O. 1970, c. 332, s. 31(3).

March. In March of 1970, the OWRC ordered all Ontario chlor-alkali plants to "reduce mercury losses to water courses to the lowest practicable level".[14] These orders were issued under the authority of Section 50 of the OWRCA[15] which required all sewage treatment plants to be operated in such manner as may be directed from time to time from the OWRC. The OWRC 1970 annual report stated that no prosecutions were necessary under section 50 because each plant was considered to be in compliance with these orders. One technical journal reported that in November of 1971 the OWRC was still pushing for zero mercury discharge from Dow's Sarnia plant, and that as a result of this pressure, Dow considered it more economical to close its mercury cell operations and replace them with one large diaphragm plant.[16]

The federal and provincial reports describing the above regulatory activity take full credit for causing the reduction in mercury discharge. Had mercury discharge continued unabated, it seems likely that courts would have found the plants to be in violation of either the federal Fisheries Act or the Ontario Water Resources Commission Act, if not both, even before passage of the federal Chlor-Alkali Mercury Regulations in March of 1972, by which time the bulk of the reduction had already been achieved. At that time however there was no reason to believe that penalties levied by the courts would be substantial. The 1970 penalty of $1,000 was trivial compared to the ultimate cost of controlling this discharge. Even after the penalties were increased in June of 1970 the

---

14 OWRC, Annual Report, 1970, Toronto: Queen's Printer, p. 225.

15 R.S.O. 1970, c.332.

16 Chemical engineering, November 15, 1971, p. 88.

Ministry did not make it a practice to monitor and lay charges for more than a handful of separate days, even when a firm was suspected of continuous excessive discharges. Thus until a firm had once been convicted on a number of counts, its expected penalties would be quite low. The fines under the OWRCA of $5,000 for a first conviction and $10,000 for a subsequent conviction were subject to the same disability: a firm would not reasonably anticipate that it would be prosecuted successfully on a sufficient number of charges to impose large liability, at least until after a first conviction. The real risk was not the prospect of fines, or even jail sentences, which a court would be most unlikely to impose, but the threat of an order to halt the discharge. Given the scientific proof of a causal relationship between mercury discharge and dangerous contamination of fish, the factual basis existed to allow the Ministry to issue orders under the OWRCA section 31.-(3) or the Fisheries Act section 33(7) which was adopted in 1970 and amended in 1977.[17]

While no charges were laid against the industry in the early 1970s, the demands made by the federal and provincial governments, and a lawsuit launched by the provincial government in March 1971 demonstrated the political will to insist on considerable reductions in this discharge. The government's will was undoubtedly strengthened by several factors. First, by 1970, scientific research established a clear causal link

[17] The 1977 amendment allowed an order not only to cease an activity (pollution) but also to take any specified action (install specific controls). S.C. 1976-77, c. 35.

between the discharge of mercury from these plants and high concentrations of mercury in fish. Second, experience in other countries demonstrated that regular eating of contaminated fish could lead to serious disease. The health effects of eating mercury contaminated fish were underscored by the government's own ban on fishing in the most seriously affected waters. Indian bands and others who regularly caught and ate those fish were both identifiable and clearly at risk. This created a constituency with a very strong interest in remedial action, unlike many pollution situations where the consequences are felt in minute ways by large diffuse groups. While the victims of this pollution contamination are groups not ordinarily very powerful in either provincial or federal politics, the clear danger to them strengthened their case considerably.

The pollution sources included firms of substantial size, where significant political influence might have deflected demands for action. One factor, however, may have constrained such resistance as the industry might have contemplated. Action to control mercury discharges took place simultaneously all across Canada, affecting all mercury cell producers of chlorine. No one firm and no one province's firms could feel disadvantaged, because their competitors would face similar cost pressures. While it is true that chlorine produced by the mercury process had to compete with chlorine produced by the diaphragm cell process, the latter was apparently somewhat more expensive, and/or produced a lower quality product. Controlling mercury discharges apparently raised the cost of mercury production to a level similar to or not far above the cost of diaphragm cell production. This interpretation

is supported by the fact that virtually all mercury cell plants in fact installed controls during the 1970-1972 period.

C. Tort Liability

At common-law, pollution discharge might be attacked under the doctrine of riparian rights, private nuisance, public nuisance, or even strict liability. Of these, the most relevant to this water pollution problem would be riparian rights, although public nuisance may be invoked by governments.

The doctrine of riparian rights entitles the owner of land adjacent to a stream to the flow of water undiminished in quality or quantity.[18] The riparian owner need show only damages in law, not damages in fact[19] meaning that a demonstration that the quality of the water has been degraded is sufficient for recovery, without a showing that this has injured the plaintiff in any way. Because riparian owners are entitled to an injunction as well as damages,[20] this doctrine is regarded as a powerful one in cases where it applies. Surprisingly, there is no record of litigation based upon riparian rights in the mercury pollution cases. The reason may stem from the unusual mechanism by which mercury harms the environment. The mercury discharged by the plant is initially inert, and settles to the bottom of the stream. Once the methylation process occurs, the mercury can move up the food chain, becoming concentrated in fish. While this may render the fish unfit for human consumption, it

---

18 McKie et al v. K.V.P. Co. Ltd (1948), [1948] O.R. 398; 3 D.L.R. 201 (H.C.).

19 Ibid.; John Young & Co v. Bankier Distillery Co. (1893) [1893] A.C. 691 at 698 (H.C.).

20 Ibid.

does not itself represent a change in the quality of the water. In fact, the water itself may still be perfectly suitable for all domestic purposes including drinking. A riparian owner, perhaps a cottage owner, might not succeed in convincing a court that the quality of the water had been impaired for any use he might make of it. While the fish may have become inedible, the riparian owner has no rights with respect to the fish themselves.[21] Thus it is not clear that a riparian owner could succeed in enjoining the chlor-alkali plant from discharging mercury.

Another tort doctrine that has been used somewhat in the environmental area is the law of public nuisance. Generally speaking however it is up to the state to protect the public against nuisances that affect the general public. Only where private individuals can show "special damages" have they been allowed to pursue public nuisance actions.[22] Canadian cases have generally noted that a fisherman does not own the fish until he has caught it, and that his rights against those whose pollution damages fish life are limited.[23]

In fact, three law suits launched against the chlor-alkali plants were based on public nuisance. On April 28, 1970, the State of Ohio filed a federal suit against Dow Canada, Dow's U.S. parent, and Wyandotte Chemicals (Michigan) seeking a declaration that the discharge of mercury

---

21 McKie et al. v. The K.V.P. Co. Ltd (1948) Ont. H.C.O.R. 398; 3 D.L.R. 201.

22 Hickey v. Electric Reduction Co. of Canada, Ltd (1970), 21 D.L.R. (3d) 368 (Nfld S.C.).

23 Ibid.; Fillion v. New Brunswick International Paper Co. (1934) [1934] 3 D.L.R. 22 (N.B.S.C.T.D.). See Alastair R. Lucas, "Legal Techniques of Pollution Control: The Role of the Public" (1974) 6 U.B.C.L. Rev. 67 at 172).

into Lake Erie was a public nuisance and requesting an injunction and damages. The U.S. Supreme Court declined to hear the case[24] and Ohio declined to pursue its case in the state courts.[25] Another lawsuit was launched at about the same time against Dow Canada by a group of commercial fishermen who fished Lake Erie and Lake St. Clair. The suit resulted from the fishing ban imposed by the Federal Fisheries Department and claimed damages for lost income. The rights of fishermen in such cases are limited, and these fishermen abandoned their suit when Ontario brought its own action the following year.[26] The fishermen and bait dealers eventually received a total of $250,000 from Dow as part of the settlement of Ontario's suit against that company.

In March 1971, Ontario launched its own lawsuit against Dow and its U.S. parent company, claiming $25,000,000 for general damages to the natural environment, fisheries, and wildlife. $10,000,000 was asked in addition in the event that mercury removal from the river and lake beds was unsuccessful. Industry observers suspected when this suit was brought that "much of Ontario's posture is probably grandstanding since there is no indication that it is dissatisfied with the efforts of chlor-alkali producers to meet the government's aims for zero mercury emissions."[27] No other lawsuits were launched pending the outcome of this test case against Dow. In the event, the Dow suit was delayed by a

---

24 Ohio v. Wyandotte Chemical Corp. et al., 401 U.S. 493 (1971).

25 Chemical Week, March 31, 1971, p. 15.

26 Chemical Engineering, July 27, 1970, p. 85.

27 Chemical Week, March 24, 1971, p. 12.

series of procedural motions by the defendant and was finally settled in June of 1978. The decision to settle was apparently influenced by doubt about the outcome of its suit because of its complexity, and by the fact that by the mid-1970s the waters were recovering much faster than had been expected.[28] The company's prompt reduction of its emissions was also cited as a justification for dropping the suit.[29]

An additional important lawsuit was brought by the crown in right of Manitoba against Interprovincial Cooperatives Limited (IPCO) and Dryden Chemicals, under the Fishermen's Assistance and Polluter's Liability Act.[30] This provincial legislation purported to allow the province of Manitoba to sue polluters' of Manitoba's waters on behalf of fishermen who were deprived of their livelihood by virtue of governmental fishing bans due to hazardous levels of pollution. While the Act was struck down as unconstitutional in 1976,[31] the constitutional issues raised in the case were complex, as evidenced by the widespread use of the opinion in the case in constitutional law courses. It must have been quite unclear in 1970 or 1971 that the firm would not be held liable. The industry's actions in 1970 and 1971 may have been substantially influenced by the

---

28 Personal conversation with John Swaigen, July, 1987; Toronto Globe and Mail, November 23, 1977, p. 7.

29 Toronto Globe and Mail, November 23, 1977, p. 7.

30 R.S.M. 1970, c. F100, C.C.S.M. F100.

31 Interprovincial Co-operatives Ltd. v. Manitoba (1975) [1976] 1 S.C.R. 477, 53 D.L.R. (3d) 321.

possibility that fishermen would manage to recover considerable amounts of money from plants that continued to discharge mercury.

Thus, at time that the chlor-alkali industry was deciding to reduce its emissions, it was subject to several large lawsuits, the outcome of which could not confidently be predicted by lawyers at the time. While the lawsuits were asking damages for past pollution discharge, it seems plausible that the government plaintiffs would temper their pursuit of the cases depending upon the industry's behavior. There would seem to be considerable force to the suspicion that the motive behind the Ontario lawsuit was strategic rather than a desire for compensation for past harm, and this in fact is apparently confirmed by statements made at the settlement itself. Were the mercury discharge to continue unabated, the plaintiffs would undoubtedly have pressed on seeking an injunction which might then have been far more important than the claimed damages. Faced with 99 per cent reductions in emissions, and rivers that were recovering rapidly, further pursuit of the litigation could have seemed pointless.

D. Other Pressures

There was considerable media coverage of the mercury problem and the attendant difficulties for the fishermen and native bands who were most directly affected around 1970. The spectre of native groups, being first poisoned and then deprived of their normal source of both food and livelihood by large industrial concerns made them an object of considerable public sympathy, generating public support for action to reduce or eliminate the problem. Whether that action was to be expressed through prosecutions under existing legislation or through public nuisance actions by governments, the industry could have seen that it

would be under intense pressure. Although there were not strong precedents for success on either the prosecution or the civil remedy actions, the risks to the industry were clearly high. The threat was not a consumer boycott, since consumers are not significant purchasers of this chlorine, but of legal action by governments, or perhaps private individuals.

The industry's response was certainly aided by the fact that relatively simple measures apparently accomplished considerable reductions. This was not a case where new technology must be developed to deal with the problem. On the contrary, good housekeeping and the use of existing waste treatment facilities to treat the mercury laden wastes could be implemented almost at once. Other control technology already existed, awaiting the decision to purchase and install. While reports indicate that capital costs for controlling mercury ultimately reached close to a million dollars in some plants, there was an offsetting recovery of mercury which at the time was being lost at the rate of a million dollars per year. The net cost to the industry of its control actions then was substantial but not unbearable. In short, once the industry decided to act, neither technology nor cost barred the way to virtually complete pollution control.

E. Conclusion

I conclude that the dramatic reduction in mercury discharge in the early 1970's resulted not from a single cause but from a combination of forces. The adoption of quantitative discharge standards may have been important, but probably no more important than the adoption of the same emission rates as guidelines earlier. Indeed, the major reduction in

emissions occurred while only the guidelines were in place, suggesting that the ability to prosecute for violations of the general prohibitions in the OWRCA or the Fisheries Act, or to order that the pollution stop may have been as important as the ability to prosecute for violations of the regulations themselves. The tort lawsuits launched in both the United States and in Canada, while their outcomes may have been uncertain, raised the possibility of very substantial liability, greatly exceeding any fines that might be imposed for violating pollution legislation. The costs of controlling the effluent, while not insignificant, were not so large as to cause major resistance to this set of forces.

V. Sulphur Oxides in Ontario: Slow Progress.

A. Overview of the Problem.

In 1970, the four major sources of sulphur dioxide air pollution in Ontario discharged close to three million tonnes per year[32] of sulphur oxides into the air. The principal concern that these discharges raised at that time was with respect to local air quality problems in the vicinity of the sources. The Sudbury area was notorious for serious pollution problems, and the surrounding landscape revealed damage that had accumulated over the previous century. At this time there was little concern about the harmful consequences of long range transport of sulphur oxides, now popularly referred to as acid rain. While scientists had discovered the acidification of Ontario lakes in the 1960s, the public was generally unaware of the problem. The first government regulations

---

[32] Tonnes refers to metric tonnes, ton refers to Imperial measure.

controlling sulphur dioxide emissions were issued between 1969 and 1971. Some aspects of the regulations or orders were not met and were subsequently relaxed, or the effective date delayed. During the 1970s, scientific awareness and concern regarding the harm caused by sulphur oxide pollution increased, as did governmental attention to the problem. The first major public conference on acid rain was held in Toronto in November, 1979 (ASAP, 1979.) Throughout the period from 1970 until 1986, the major sulphur dioxide sources gradually reduced their emissions until by 1986 the total discharge in Ontario was roughly one half that in 1970.

While mercury in waste water could be controlled to a large degree at a moderate cost with proven technology, controlling SO_2 emissions from all four sources required technology that was unproven at the time, and would cost many tens of millions of dollars. Smelters differ in their processes, and in the composition of the ore that is roasted, requiring different pollution control approaches. In the early 1970's Falconbridge installed controls costing tens of millions of dollars, only to find that they failed to perform. The "scrubbers" which were regarded at the primary SO_2 control technology for coal-fired power plants were both costly and of dubious reliability, producing a prodigious amout of waste material as an unwanted by-product. As is often the case with air pollution control, the control problem for SO_2 was far more daunting than was the problem of controlling water pollution such as mercury.

B. Regulation

The first Ministry of the Environment control order for Inco in Sudbury was issued in 1970. This order required the construction of the

381 meter tall "superstack" intended to relieve the serious local environmental and health problem. This control order also required progressive reductions in total SO_2:

5,200 tons (4717 tonnes) per day by July 1, 1972;

4,400 tons (3992 tonnes) per day by December 31, 1974;

3,600 tons (3266 tonnes) per day by December 31, 1976;

750 tons (680 tonnes) per day by December 31, 1978.

The 3600 tonne per day limit was achieved by 1973, three years ahead of schedule, primarily as a result of the installation of a concentrator which separated material high in nickel and copper from material with less nickel and copper and more sulphur.[33] The concentrator reduced SO_2 emissions and at the same time increased the production efficiency of the smelter.

In 1973, a Sudbury environmentalist charged Inco with violating a smoke density regulations, and succeeded in imposing a fine of $1,500. In May of 1974 the Ministry won a conviction of Inco for sulphur dioxide discharges in excess of the amount allowed under a control order, securing a fine of $2,500. We have not discovered any other convictions of Ontario's sulphur dioxide sources for violation of provincial statutes or regulations during the 1970s.

By 1978 it became apparent that Inco would not meet the 1979 target of 750 tons (680 tonnes) per day, and a new control order was issued continuing the 3600 ton per day limit until June 30, 1982. The continuation of the 3600 ton per day limit seems to have reflected Inco's concern about the cost of further reductions (concern that aroused some

[33] Ontario, Standing Committee, (1979, p. 37).

sympathy at the Ministry), and continuing questions about the actual impact of Inco's discharges on the environment. The Ontario Standing Committee on Resources Development (1979, p. 39) concluded that the Ministry deferred further regulation because of "the conviction that the environmental benefits of costly efforts to reduce emissions from current levels will be negligible".

In 1980, a new set of emissions limits was established at the level of 2268 tonnes per working day from 1980 until the end of 1982, and 1769 tonnes per working day thereafter. In 1985, the Countdown Acid Rain program imposed limits of 685,000 tonnes per year effective in 1986, and 265,000 tonnes per year beginning in 1994. This regulation further provides public funds to subsidize the achievement of targets that are deemed beyond the financial reach of the company.

This brief history reveals two stark facts. First, while Inco succeeded in making substantial reductions in emissions over an extended period of time, dramatic expensive reductions (more than 75 per cent for 1978) although ordered by the Ministry, were not even attempted. In 1975 Inco proposed to the Ministry a plan that would reduce SO_2 emissions to 1500 tonnes per day by December 1979 at a cost first estimated at $200 million, soon raised to $300 million. While this plan appears expensive, it would have yielded revenues from the sale of acid that not only exceeded the direct costs, but earned a projected after-tax rate of return of 6.7 percent, assuming the $200 million cost (Felske, 1981, p. 172.) Inco abandoned this plan, on the grounds that it was not profitable, when increases in the projected capital cost and a fall in the projected price of sulfuric acid reduced its rate of return to 3.9

percent. Thus Inco's criterion for proceeding with major pollution control projects was that they yield a profit to the firm, and indeed, the projects of the early 1970's reduced costs or improved efficiency as well as reducing SO_2 emissions. The firm was prepared to expend only limited amounts on projects that yielded no benefits other than pollution control. Since converting its SO_2 emissions to sulphuric acid would produce colossal amounts of acid, the market price of this acid would be depressed, contributing to the economic unattractiveness of control plans.

The second fact that emerges from the history is that the penalties imposed by the Ministry are trivially small. The control program that Inco proposed in the mid 1970's was to cost $300 million. The total penalties paid by Inco for SO_2 emissions during the same decade amounted to a few thousands of dollars. It is not apparent that the Ministry was prepared to impose any significant penalties on Inco for failing to meet emission limits or deadlines. The emissions of Inco and the various control orders are shown in Table 4.

Falconbridge Limited received its first sulphur dioxide control order in November 1969. This order required a reduction to 465 tons per day by 1975. By 1973, it was apparent that the control technology upon which Falconbridge was relying would not work, and the Ministry issued a new control order essentially delaying the 465 ton per day requirement to May of 1979. In 1977 the control order was once more amended due to a lengthy strike and adverse economic conditions, further postponing the 465 ton (422 tonne) per day limit. The Countdown Acid Rain program set

an emission limit of 154,000 tonnes per year (equal to 422 tonnes per day) for 1986, and 100,000 tonnes per year at the end of 1994.

Interestingly, while Falconbridge appears not to have been prosecuted or penalized for sulphur oxide emissions its annual and daily emission rate have declined considerably since 1969. In 1981, emissions per operating day were less than 40 per cent of the 1969 emissions. This considerable reduction was achieved without any apparent sanctions being imposed on Falconbridge. While it is hard to believe that the Ministry's regulatory efforts did not have a substantial impact, it is impossible to demonstrate that from the record here.

The third polluter, Ontario Hydro, was under no specific control orders regarding sulphur dioxide emissions until 1981. Nonetheless, in the mid 1970s Hydro began to do research on the frequency of acid rain events, and commenced buying washed coal, which had the effect of reducing sulphur content by 15 to 20 per cent. In the late 1970s, low sulphur western coal was mixed with U.S. coal, increasing fuel costs by approximately $35 million per year. In 1981, the Ministry issued O. REG. 73/81, which limited sulphur dioxide emissions to 390,000 tonnes per year in 1986 and 260,000 tonnes per year after 1989. These limits were modified in 1982. The Countdown Acid Rain regulation, O.REG. 662/85, imposes limits of 370,000 tonnes per year in 1986, 240,000 tonnes per year in 1990, and 175,000 tonnes per year at the end of 1994. Flexibility is introduced into this regulation by allowing Hydro to bank any short fall of its emissions with regard to the standard and draw upon the shortfall in subsequent years if its emissions exceed the limit.

Again, there is no evidence of penalties or sanctions being imposed on Ontario Hydro. Nonetheless very substantial amounts of money have been spent to date to control emissions of sulphur oxides.

The Wawa plant of Algoma Steel has been the least significant of the four major sources of sulphur dioxide in the Province. The first control order was issued to Algoma in 1971, and after amendment in 1973 limited emissions to 285,000 tonnes per year. Unlike the other three sources, it has installed no equipment for controlling SO_2 emissions. The Countdown Acid Rain Program reduced Algoma's emission limit to 180,000 tonnes per year at the end of 1986, which will drop to 125,000 tonnes per year in 1994. In 1980, the plant emitted 161,000 tonnes, and during the last few years it has emitted still less, because of operations at less than capacity, reflecting reduced demand for its product.

C. **Tort Liability**

I have not discovered tort lawsuits against the major sources of sulphur dioxide emissions since 1970. One might expect successful lawsuits based upon the principles of private nuisance, to the extent that a landowner could demonstrate either interference with the use and enjoyment of his property or could demonstrate actual physical damage, caused by a particular pollution source. The absence of such litigation may be attributed either to problems of proof by a plaintiff, or to defenses available to the defendant.

The first problem of proof would be to establish that the harm in question was caused by sulphur dioxide pollution. The connection between sulphur dioxide and health effects is uncertain and not at all specific to this pollutant, and it seems unlikely that a downwind resident could

demonstrate that his or her respiratory ailments were attributable to sulphur dioxide emissions. The connection between these emissions and injury to growing plants is no more easy to prove, unless there is acute injury. There is continuing debate regarding the harm that may be done by acid precipitation, with few clear answers that are generally accepted in the scientific community. Even if plaintiff managed to establish that his harm arose from sulphur oxide pollution, he would face the second problem of proving that the source in question caused the SO_2 concentration at the plaintiff's property. A property owner near a large source of low level emissions may manage to establish this "transport" relationship. If the source is far away, it may be very costly or even impossible to prove that the source caused or even significantly contributed to the plaintiff's harm. If the harm arises from acid deposition, there is the difficult problem of proving what proportion of the acid deposition in a particular area may have originated at a particular pollution source hundreds or thousands of miles away. Proving both of these elements of causation would be expensive and uncertain, although increasing scientific knowledge during the 1970's has probably improved the feasibility of such proof.

Three defensive barriers still block the potential plaintiff: prescription, considering the neighbourhood, and statutory authority. The defence of prescription seems to be available in private nuisance actions if the harm continued for twenty years and the victim had actual or constructive knowledge of it.[34] To the extent that discharge rates

---

[34] Russell Transport Ltd. v. Ontario Malleable Iron Co. Ltd. (1952), 4 D.L.R. 719 (H.C.).

after 1970 did not exceed those of 20 years earlier, a prescriptive right might have been earned.

Furthermore, if a private nuisance action is based upon interference with use and enjoyment of land, the court will consider the reasonability of the activity causing the nuisance considering the neighbourhood.[35] Where a smelter has existed for many years, the neighbourhood is sure to be considered industrial, and some pollution discharge will be regarded as an inevitable consequence of that activity. Finally, the action of the Ministry in issuing control orders specifying allowable discharge rates may actually give rise to a defense of statutory authority, to the extent that the defendant has complied with the order.

Taken together, the above points suggest a low likelihood of success in any private nuisance litigation. If one looks at the successful private nuisance actions for air pollution in Ontario, they are generally associated with acute pollution episodes rather than with chronic low level problems. There is little case history to encourage a plaintiff to sue any of the four major sources. Only a plaintiff with very large dollar claims would be likely to invest in a risky lawsuit against a large defendant who would have every incentive to resist vigorously the first lawsuit of what could become, if it were successful, an avalanche of such litigation. One might argue however that as knowledge of the transport and harmful effects from sulphur dioxide emissions increased during the 1970's, and as public and private concern about pollution increased, the possibility that a court might find a legal basis for sustaining a plaintiff's claim also increased. In this situation,

---

[35] Huston v. Lloyd Refineries Ltd. (1937), O.W.N. 53.

prudence would suggest making significant efforts to reduce pollution discharge.

D. Public Image

All four major sources of sulphur dioxide are large visible corporations. Ontario Hydro sells directly to the public in some parts of the province, but is visible to the public everywhere. Private citizens intervene in Ontario Hydro rate hearings on a regular basis, as have environmental groups since the early 1970s. Hydro expends significant resources to protect and preserve its public image, and could be expected to respond to public concerns about sulphur dioxide emissions when those concerns became widespread. As a monopolist, Hydro can pass along the costs of pollution control to its customers, although it pays a political price for every rate increase that is achieved. It seems quite likely that public pressure played some part in Hydro's sulphur dioxide control program.

The other three sources are further removed from the public in that they sell intermediate goods, not consumer products. One might expect them to be largely indifferent to public opinion. On the other hand, as citizens of their own communities, they would be expected to respond to local concerns about environmental matters, if not to concerns from other parts of the province. Furthermore, as large enterprises that have continual dealings with many branches of government, they must attach some cost to developing a reputation for disregarding government regulations. While it is impossible to quantify the importance of this

factor, it seems plausible that public concern would lead to some pressure for pollution reduction from the remaining three sources.

E. U.S. Regulations

The U.S. smelting industry has been required to install expensive sulphur dioxide controls in new smelters and even in existing smelters. New coal fired power plants in the United States are required to install expensive scrubbers to remove sulphur dioxide from their stack gases. While the four major pollution sources here are not directly affected by U.S. regulatory policy, it is possible that the development of increasingly stringent U.S. regulations set a climate in which spending money to reduce emissions in Ontario would seem reasonable.

F. Scientific Evidence

We have mentioned the advances in scientific knowledge about the long range transport of atmosphere pollutants and the effects of acid rain. While there is still considerable uncertainty surrounding these issues, such that the United States government can still maintain that the damage from acid rain is not proven, (NAPAP, 1987) the evidence of a connection between sulphur dioxide emissions and harmful environmental effects has been accumulating gradually since the early 1970s. In 1979 and 1980, the connection was still regarded as uncertain and unproven. The Ontario Standing Committee on Resources Development (1979, p. 39) concluded:

> There is general concensus that local damage to the environment in the Sudbury region has been markedly reduced since the construction of the superstack and the partial abatement of sulphur dioxide emissions, and that the more widespread problem of acidic

> precipitation outside the Sudbury region cannot be solved by abatement at Inco facilities alone, because of the very great contributions made by pollutants from other sources, largely in the United States. On the other hand, Inco emissions at currently accepted levels are considered by at least some experts to have significant negative effects on both local and more distant environments.

A 1980 Ministry of the Environment document, "The Case Against the Rain" (Ontario, MOE, 1980,) wavers between concern over possible effects, suspected but still unproven, and concern over costs. The then minister Dr. Parrott is quoted as saying:

> In the long-term we must weigh the efficiency of various abatement methods against the actual problem. The cost of such abatement runs into billions of dollars, and cannot be entered into lightly, without firm evidence that they will successfully perform. (Ontario, MOE, 1980, p. 15.)

By the min-1980's, when the Countdown Acid Rain program was developed, the Ministry regarded the link between emissions and acid rain as proven:

> Environmental studies have proven that the sulphate deposition resulting from SO2 emissions is the primary cause of surface water acidification (Ontario, MOE, 1985, p. 2).

The report goes on to list damages caused by acid rain and by SO2 itself (Ontario, MOE, 1985, p. 3).

Certainly there was no evidence of serious harm connected with sulphur oxide emissions comparable to the very strong evidence existing in 1970 regarding the serious health effects resulting from mercury discharge. It is hard to escape the conclusion that the absence of proven serious health effects was a major factor in the much slower pace of sulphur dioxide control in Ontario.

G. Conclusions

The slow pace of sulphur dioxide control is not primarily the fault of inadequate penalties: the Ministry did not begin to utilize the penalties that were available during the 1970's. Furthermore, the mercury success occurred with available penalties no greater than those applicable to sulphur dioxide. The absence of serious tort lawsuits removed one potentially powerful incentive to pursue lower emissions. Certainly the large costs of control, and the uncertain effectiveness of available technology dampened the enthusiasm of the industry for reducing emissions. Finally, the uncertain link between emissions and substantial harm robbed the Ministry, and the major sources, of the will to commit great resources to the resolution of the problem.

VI. Conclusions

The regulatory activity and the response of the polluters to the two pollution problems discussed here could not be more different. Mercury discharge was reduced by 99 per cent within years, while sulphur dioxide emissions dropped 50 per cent in fifteen years. The explanation for this difference is however far from simple. In neither case did regulatory agencies impose substantial sanctions or penalties. Neither can the results be explained by the offer of substantial subsidies. The notion of a government agency directing the hand of industry with a firm grasp simply seems inapplicable in both situations.

Rather, the difference in outcomes seems attributable to several important differences in the cases. Mercury was proven to cause serious health problems, a fact emphasized by banning the consumption of fish in

the affected rivers. In contrast, human health effects from sulphur dioxide inhalation at the levels prevalent in the 1970s were speculative at best as were allegations of wider environmental harm. The mercury in a river could generally be traced unambiguously to a single source, while only the local sulphur dioxide pollution could necessarily be traced to its source. Tort lawsuits were brought against mercury polluters and while not highly successful they dragged on for many years presenting the spectre of potential large recoveries. In contrast, I have not discovered major actions brought against the major Ontario sulphur dioxide sources during the period in question. Mercury discharge could be controlled to a great degree by readily available technology at a moderate cost, while the cost of SO_2 control was high, and the technology unproven. Finally, the harm caused by sulphur dioxide was felt over a large number of individuals in very small amounts. In contrast, a relatively small number of individuals was substantially affected by the mercury pollution: their very way of life was threatened and altered.

These differences in the character of the problem, the scientific information, the nature and distribution of the harm all work together to lead to different outcomes. These outcomes are developed through the regulatory system, through tort litigation, through public pressure, and through the firm's own self interested actions. While this research is not yet completed, I hypothesize that there is a general principle here. In cases where regulatory action seemed to have been particularly successful, one may find that this regulation does not exist in a vacuum. Rather, the factors which make regulation successful also yield other pressures such as tort liability and public opinion leading toward the same outcome.

REFERENCES

Anderson, Frederick R.; Kneese, Alan V.; Reed, Philip D.; Taylor, Serge; and Stephenson, Russell D. Environmental Improvement Through Economic Incentives. Baltimore: Johns Hopkins Press, 1977.

ASAP. Action Seminar on Acid Precipitation: Proceedings. Toronto: ASAP Coordinating Committee, 1979.

Baumol, William A., and Oates, Wallace E. Economics, Environmental Policy, and the Quality of Life. Inglewood Cliffs, New Jersey: Prentice Hall, 1979.

CEQ. Council on Environmental Quality. Environmental Quality. Washington, D.C.: U.S. Government Printing Office, published annually.

Commoner, Barry "A Reporter at Large", The New Yorker, June 15, 1987, p. 46.

Crandall, Robert W. Controlling Industrial Pollution: The Economics and Politics of Clean Air. Baltimore: Johns Hopkins Press. 1983.

Donnan, J. A. and P. A. Victor. "Alternative Policies for Pollution Abatement: the Ontario Pulp and Paper Industry; Summary and Update, Volume III." Toronto: Ontario Ministry of the Environment, June, 1976.

EPS. Environmental Protection Service, Environment Canada. Status Report on Compliance with the Chlor-Alkali Mercury Regulations 1982-83. EPS 1/HA/1. Ottawa: Ministry of Supply and Services. March, 1985.

Felske, Brian, and Assoc. "Sulphur Dioxide Regulation and the Canadian Non-Ferrous Metals Industry." Technical Report No. 3, Regulation Reference. Ottawa: Economic Council of Canada. 1981.

Flewelling, F. J. "Canadian Experience With the Reduction of Mercury at Chlor-Alkali Plants", in P. A. Krenkel, ed., Heavy Metals in the Aquatic Environment. Oxford: Pergamon Press, 1975.

Magat, Wesley A. and W. Kip Viscusi. "The Effectiveness of EPA's Enforcement: The Case of Industrial Effluent Standards". AERE Workshop on Environmental Monitoring and Practice, Newark, Delaware, Aug 13, 14, 1987.

Mills, Edwin S. and Philip E. Graves. The Economics of Environmental Quality. 2nd. ed. New York: Norton. 1986.

NAPAP. National Acidic Precipitation Assessment Program. News Release, Washington, D.C. September 17, 1987.

Ontario, Ministry of the Environment. The Case Against the Rain. Toronto: Ontario Ministry of the Environment. 1980.

Ontario, Ministry of the Environment. Countdown Acid Rain: Ontario's Acid Gas Control Program for 1986-1994. Toronto: Ontario Ministry of the Environment. 1985.

Ontario, Standing Committee on Resources Development. "Final Report on Acidic precipitation, Abatement of Emissions From the International Nickel Company Operations at Sudbury, Pollution Control in the Pulp and Paper Industry, and Pollution Abatement at the Reed Paper Mill in Dryden". Toronto: Ontario Legislature, 1979.

Tietenberg, Thomas H. Emissions Trading: An Exercise in Reforming Pollution Policy. Baltimore: Johns Hopkins Press. 1985.

Troyer, Warner. No Safe Place. Toronto: Clark, Irwin & Company. 1977.

Wasserman, Cheryl. "Environmental Compliance and Enforcement: Theory, Practice, and the Challenge to Environmental Economists". AERE Workshop on Environmental Monitoring and Enforcement, Newark, Delaware, August 13, 14, 1987.

Table 1

Air Quality Trends in Ontario[1]
Annual Average, All Stations

Year	Sulfur Dioxide (ppm)[2]	Nitrogen Dioxide (ppm)[2]	Total Suspended Particulates (ug/m^3)[3]	Carbon Monoxide (ppm)[2]	Lead In TSP (ug/m^3)[4]
1971	.038		95	3.7	1.0
1972	.025		96	4.4	1.8
1973	.015		90	4.2	1.4
1974	.014	.032	76	2.8	1.4
1975	.012	.029	65	2.2	1.2
1976	.013	.027	64	1.6	1.3
1977	.011	.031	61	1.6	0.9
1978	.009	.028	59	1.6	0.6
1979	.008	.024	65	1.6	0.5
1980	.008	.022	63	1.4	0.4
1981	.009	.021	53	1.4	0.4
1982	.006	.021	49	1.2	0.3
Ontario Objective (Annual)	.02	0.1 (24 hr)	60	13 (8 hr)	5.0 (24 hr)

1. Ontario Ministry of the Environment, "Air Quality Trends in Ontario 1971-1982". Report ARB-131-84-AQM. Toronto: MOE, 1984.

2. Network average, parts per million. Table 5, Table 9, Table 6.

3. Network average of geometric means, micrograms/cubic meter. Table 3.

4. Network average, micrograms/cubic meter. Table 13.

Table 2

Mercury Discharged with Liquid Effluent (Kilograms/year)[1]

Company	1970	1971	1972[2]	1973[3]	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Alcan	5018[7]		33.1	40.8	43.5	34.9	13.3	Closed June 1976						
American Can	1534[7]		12.7	18.6	71.7	14.1	20.0	10.7	Closed September 1977					
Canso	572[5,7]		9.1	14.1	10.0	10.4	6.4	7.9	4.9	6.4	7.0	6.6	6.6	5.3
CIL Cornwall	5096[7]		28.6	41.3	41.7	42.2	22.7	15.0	30.0	29.0	31.8	29.9	20.0	19.9
CIL Dalhousie	3614[7]		31.7	31.7	17.2	11.3	15.0	12.0	28.0	10.0	9.1	10.7	6.0	6.4
CIL Hamilton	3731[7]				Closed June 1973									
CIL Shawinigan	4251[7]		27.2	45.8	59.2	44.9	31.0	27.0	18.0	15.0	Closed January 1979			
Domtar	1755[7]		112.9	74.4	44.0	23.1	30.0	36.4	32.1	Closed May 1978				
Dow Sarnia 1	11752[7]				Conversion January 1973									
Dow Sarnia 2					Conversion July 1973									
Dow Thunder Bay	3393[7]				Closed September 1973									
Dryden	1404[7]		2.3	2.3	1.8	5.0	Conversion October 1975							
FMC	6552[7]		15.0	29.0	25.4	24.0	33.9	25.1	35.0	27.3	23.2	19.3	16.8	20.0
Prince Albert Pulp	2756[7]		11.3	13.6	9.1	4.5	6.1	6.0	7.0	Conversion November 1978				
Stanchem	5213[7]		705.2	84.4	76.2	65.8	67.8	81.4	21.9[4]	52.0	41.9	37.3	47.2	46.5
Totals	56641[7] (67000)[6]	(3000)[6]		396.0[8]	400.0	280.2	246.2	221.5	176.9	139.7	113.0	103.8	96.6	98.1

1. All figures are company reported data from Status Reports unless otherwise noted.
2. Data available for May to December 1972, only.
3. 1972, 1973 data converted from pounds to kilograms using 1 kg = 2.205 pounds.
4. Based on 3 months production at Stanchem, 1978
5. Canso started operation in August, 1970.
6. Sums available from status reports although individual company data for 1970/71 is not available.
7. Flewelling (Royal Society of Canada's Symposium on Mercury in Man's Environment) estimates that for an average Canadian chlor-alkali plant in 1970, 26 pounds of mercury per 100 tons of chlorine produced was discharged to sewer. (26 lbs/100 tons = 130 g/tonne). The Status reports also estimate a discharge rate of 130g/tonne for 1970. This estimate is combined with the estimates of 1970 chlorine production at each plant (table 4) to yield these estimates of mercury discharged at each plant.
8. This sum does not include discharges from those plants which were closed in 1973.

Table 3

Mercury Discharged with Liquid Effluent (Grams per tonne of Chlorine produced)[1]

Company	1970	1971	1972[2]	1973[3]	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Alcan			1.45	1.10	1.05	1.30	1.01	Closed June 1976						
American Can			1.70	1.60	6.35	1.40	1.88	1.55	Closed September 1977					
Canso			0.60	0.60	0.40	0.55	0.36	0.38	0.23	0.31	0.33	0.34	0.47	0.31
CIL Cornwall			1.05	0.95	0.85	0.97	0.61	0.39	0.61	0.58	0.67	0.76	0.53	0.53
CIL Dalhousie			1.70	1.15	0.55	0.45	0.51	0.42	0.97	0.33	0.32	0.37	0.28	0.26
CIL Hamilton					Closed June 1973									
CIL Shawinigan			1.30	1.45	1.80	1.35	1.25	1.28	0.69	1.14	Closed January 1979			
Domtar			9.00	3.40	2.00	2.00	2.26	2.10	3.35	Closed May 1978				
Dow Sarnia 1					Conversion January 1973									
Dow Sarnia 2					Conversion July 1973									
Dow Thunder Bay					Closed September 1973									
Dryden			0.30	0.20	0.15	0.60	Conversion October 1975							
FMC			0.40	0.50	0.45	0.55	0.55	0.44	0.59	0.45	0.44	0.35	0.39	0.40
Prince Albert Pulp			1.05	0.70	0.40	0.25	0.29	0.26	0.40	Conversion November 1978				
Stanchem			19.55	1.45	1.15	1.35	1.25	1.63	2.16[4]	0.96	0.83	0.72	1.01	0.90
Average[6]	130[5]		4.56[7]	1.15[7]	1.08	0.97	0.87	0.84	0.80	0.61	0.56	0.53	0.59	0.54

1. All figures are company reported data from Status Reports unless otherwise noted.
2. Data available for May to December 1972 only.
3. 1972, 1973 data converted from pounds/ton to g/t by dividing by .002.
4. Based on 3 months production at Stanchem, 1978.
5. 1970 average from Status Reports and also from Flewelling, (Royal Society of Canada's Symposium on Mercury in Man's Environment.)
6. Averages calculated from total mercury discharged with liquid effluent (Table 2) and total chlorine produced (Table 4).
7. 1972 and 1973 averages calculated only for those plants not closed prior to 1974.

Table 4

Sulfur Oxide Emissions and Limits
Inco Ltd., 1969-1986, 1994
(Metric Tonnes)

Year	Tonnes/Year[1] (000)	Tonnes/ Calendar Day[2] Actual	Tonnes/ Calendar Day[2] Control Order	Tonnes/ Operating Day[2]	Comments
1969		3589		5552	Strike year
1970	1991	5454		5454	
1971	1868	5118		5118	
1972	1519	4162	4717	4416	Summer shutdown
1973	1186	3249		3448	Summer shutdown
1974	1216	3331	3992	3331	
1975	1198	3282		3385	Strike year
1976	1191	3340	3266	3340	
1977	1137	3115		3115	
1978	567	1553	680/3266	2613	Strike year
1979	408	1118		1933	Strike year
1980	812	2225	2268	2225	
1981	723	1981		2146	Summer shutdown
1982	328		1769		
1983	459				
1984	683				
1985	695				
1986	685 regulation				
1994	265/175 regulation				

1. Ontario Ministry of the Environment, Air Resources Branch

2. Report of the Ontario/Canada Task Force for the Development and Evaluation of Air Pollution Abatement Options for Inco Limited and Falconbridge Nickel Mines, Limited in The Regional Municipality of Sudbury, Ontario. Fall, 1982.

FINANCIAL ASSURANCE

A NEW TOOL FOR ENVIRONMENTAL PROTECTION

By

J. A. Donnan*, M. B. Jackson** and J. Swaigen**
* Policy and Planning Branch
** Legal Services Branch
Ontario Ministry of the Environment

A Paper to be given at the Technology Transfer Conference
November 30, 1987

The Royal York Hotel
Toronto, Ontario

1. INTRODUCTION

Part X-A of the Ontario Environmental Protection Act was enacted in December 1986 as part of Bill 112.[1] This bill, which also contained revisions to the minimum fines for offenses under the EPA as well as provisions which make directors and officers of a corporation liable to prosecution for offenses under the Act, was given first reading on July 3, 1986 and received Royal Assent on December 18, 1986. Part X-A empowers the Ontario Ministry of the Environment to require that financial security be provided as a condition of an approval or a Ministerial order. This security, or financial assurance (FA) as it is referred to in the Act, may be provided as cash, an irrevocable letter of credit, a surety or performance bond, transferrable bonds or as an agreement to pay in the event that certain conditions are not fulfilled. Financial assurance may also be used to accumulate funds for expenses which will be incurred in the future such as clean-up or rehabilitation of waste disposal sites or mine tailings areas.

Financial assurance may not be kept as a penalty. It must be used to implement the requirements of the order or approval or it must ultimately be returned to the regulated party. Since Part X-A bestows a discretionary power, administrative guidelines are being prepared to aid Ministry of the Environment personnel in implementing this provision and to inform the public and regulated parties as to how Part X-A will be applied. To our knowledge, this provision is unique among North American environmental legislation.

In this paper, we present arguments for enacting the financial assurance provision. The origins of Part X-A are then documented together with the research and investigations which preceded passage of the provisions.

A second objective of the paper is to clarify the intent of the legislation and identify issues associated with its implementation. This will be accomplished by discussing the current status of the provision and the implementation guidelines that are being prepared. The applications to date of requirements for financial assurance (FA) by the Ministry of the Environment (MOE) will be enumerated and discussed along with the potential costs of financial assurance to regulated parties. Finally, relevant research questions and topics pertinent to this provision will be identified.

2. PERCEIVED NEED FOR FINANCIAL ASSURANCE

The prevailing approach to environmental regulation in Ontario and other North American jurisdictions is called direct regulation or the command and control system. This approach involves the establishment of environmental objectives or standards in statutes, regulations and other legal or administrative mechanisms. These objectives are stated as ambient quality concentrations, contaminant discharge loading limits, the application of specific technologies or practices or as prohibitions against environmental harm. Deadlines for the completion of required programs or the achievement of specific standards are often a condition of these objectives. Environmental agencies then rely on voluntary compliance, moral suasion, prosecutions, fines and financial assistance to get the objectives implemented. These instruments are aimed at reducing on-going contaminant discharges or cleaning up past abuses.

Another component of the current environmental protection infrastructure is directed at preventing future problems and damages. Approvals or permit requirements and the Environmental Assessment (EA) process are examples of preventative instruments. Here in Ontario, the Environmental Protection Act and the Ontario Water Resources Act (OWRA) require that a certificate of approval (C. of A.) be obtained before an individual, firm or municipality can proceed with most projects that will generate, treat, process, transport or dispose of waste materials or other types of environmental contaminants. Various conditions, emission limits and other performance standards are often included in a C. of A. Moreover, certificates of approval may be revised if the circumstances of the applicant change, at which time the terms and conditions may be amended. U. S. State and federal governments have similar discharge permit requirements and procedures.

Environmental Assessments or Environmental Impact Statements require that environmental considerations be explicitly incorporated into these feasibility evaluations. The EA process also compels proponents to show that they have examined alternative ways of achieving the specified project objectives which may have fewer adverse environmental consequences. Accordingly, the EA may be instrumental in having the proposed activity modified or even cancelled altogether.

Since the legal instruments and procedures used in Ontario to achieve prevention and abatement are typical of those found in other North American jurisdictions, experience in this province will be discussed to illustrate the need for financial assurance.

After Ministry of the Environment (MOE) staff have identified a problem and its source, efforts are then made to

secure a voluntary resolution. This may require further study by both the Ministry and the emitter, together with negotiations as to the elements of a control program. If a voluntary program is agreed upon, the polluter may proceed with implementation on its own or the program may be formalized with a program approval or a Ministerial order, either of which, if complied with, can shield the regulated party from prosecution concerning the elements in the program.2

If a voluntary program is not forthcoming, the Ministry can impose an abatement program on a polluter by means of orders issued under authority of the Environmental Protection Act or the Ontario Water Resources Act.3 These instruments, called control orders under the Environmental Protection Act and requirements and directions under the Ontario Water Resources Act, can be appealed to the Environmental Appeal Board. Decisions of this Board may be appealed to the Divisional Court on questions of law or to the Minister of the Environment for other reasons. The Minister can uphold, revoke or alter the Board's decision. Immunity from prosecution applies whether the order is the result of a voluntary program or is imposed as an order by the Ministry. An order can take up to a year to develop and issue, depending on its complexity.

While orders are the most widely used of the available enforcement instruments, regulations made under a relevant act can be a more potent tool. In addition, when there is a clear and present danger to human health, injunctions or stop orders may be imposed.4 All of these instruments are discretionary.

If a regulated party remains intransigent in the face of these actions, prosecution is the key sanction currently available to environmental agencies. If found guilty, the offender may be fined or the court may order the defendant to abate existing pollution or take steps to prevent future violations. This latter sentence is similar to a probation order. Jail sentences are also available for serious pollution offenses in Ontario. Penalty provisions under Ontario's environmental statutes have been made much more severe by the same Bill that enacted the new financial assurance authority.5

Control orders, prosecutions and fines are sometimes applied to enforce pollution control at municipal sewage treatment plants and solid waste incinerators. However, subsidies or financial assistance are more generally used by the federal and provincial governments to induce municipalities to build and install sewage treatment plants. More than $582 million has been transferred from the Ontario government to municipalities between 1977 and 1985 to help finance construction of sewage treatment plants.6

Ontario has enjoyed a substantial degree of voluntary compliance with environmental objectives from all segments of

society. There are also indications that Ministry efforts and programs are contributing to improvements in ambient environmental quality conditions as well as protecting against further deterioration.7 Furthermore, pollution control expenditures that have been stimulated by regulatory actions support a substantial amount of economic activity by firms which manufacture, install, and service pollution abatement equipment and systems as well as those which produce chemicals and instruments used in these operations.8 Moreover, there is evidence that environmental regulatory actions have stimulated investments that have increased productivity in industry.9

Nevertheless, where control costs are high and the beneficial consequences of abatement uncertain, regulated parties have often delayed implementing programs. Indeed, there are a number of controversial, long-standing industrial pollution cases which available instruments, policies and programs appear not to have been able to resolve in a timely and effective manner. These cases include non-ferrous metal smelters, lead refiners in Toronto, and the pulp and paper industry to name a few.10

Experience with these cases, together with the persistence of major industrial pollution problems throughout the world have revealed certain limitations inherent in the command and control regulatory approach. One such limitation is that most of the instruments or tools which are currently available to regulatory authorities do not appreciably alter the economic incentive structure which faces major polluters.11

When a polluting firm or municipality is issued an abatement order, it faces two alternative sets of financial consequences. If the polluter complies, abatement costs are often very large and usually very certain. If the firm or municipality does not comply, it faces non-compliance costs which include management and staff time, legal expenses, fines and adverse publicity associated with regulatory activities and prosecutions. These costs may or may not be larger than compliance costs but they are invariably much less certain. Consequently, the Expected Value of non-compliance costs are substantially mitigated by the uncertainties as to whether a polluter may be detected, charged, convicted and fined for pollution offenses.

Even when a polluter is prosecuted, the actual costs and adverse effects that are incurred by the defendant may still be much lower than direct compliance costs. Under these circumstances, a polluter has a powerful economic incentive to choose non-compliance because it will save large amounts of money by delaying or forestalling the requisite abatement actions. Also the adverse public relations or loss of "good will" that might result from a prosecution and conviction will likely have little effect on sales or operations. Non-compliance may, therefore, reflect an acceptance of low or uncertain non-

compliance costs over very high, very certain direct compliance costs.

It should be noted that recent increases in the minimum fines that were enacted in Bill 112 may have increased the perceived Expected Value of non-compliance costs. In fact, section 146c provides that, in addition to other penalties, a court can increase a fine "by an amount equal to the amount of the monetary benefit acquired by or that accrued to the person as a result of the commission of the offense..." In other words, the court can confiscate the profits from pollution if these can be estimated.

Under current laws and procedures in Ontario, orders are enforced by prosecutions and complemented by stop orders and injunctions although these latter two instruments have strict legal criteria and requirements which limit their use. Past experience has indicated that control orders themselves contain no inherent incentive qualities which would induce polluters to implement the specified requirements. In some instances, where a major polluter has agreed to a control order which specifies a costly abatement program over 3 to 5 years, company officials have informed the Ministry, only a few months before the final compliance date,that the firm would be unable to complete agreed-to abatement programs for seemingly legitimate reasons, eg. "more research is needed" or "suppliers are on strike" or "we just cannot afford it". Indeed, claims of inability to pay for abatement programs along with implied and explicit threats of closure and unemployment are familiar, but fortunately not frequent, responses from firms which face abatement orders. While financial analyses by Ministry staff and "forensic accountants" have verified only a few such claims, these procedures invariably delay progress toward the desired environmental objectives and, in the process, save the regulated party money.

The provision of financial assurance would remove the excuse of insufficient funds with which to complete a program. Moreover, financial assurance will provide an economic incentive, hitherto absent or very weak, to complete a project in a timely manner. FA cannot be confiscated as a penalty but it can be withheld until an abatement program has been implemented. The fact that funds may be tied up in this manner can also provide an incentive to notify the Ministry when requirements are completed on time in order that the Ministry can release the FA. A financial assurance requirement may also be used to establish a fund for future rehabilitation, clean-up and decommissioning of solid waste disposal landfills, mine tailings or abandoned industrial sites.

An important limitation of common law rights and remedies for the victims of pollution damages is the failure of the tort

system to ensure that funds are available to pay judgments obtained through the courts. If a defendant who is found liable for a damage has sufficient assets or insurance to pay the judgment, the judicial systems provides a mechanism to facilitate collection. However, the courts cannot ensure that funds are available unless legislation requires that individuals, firms or government agencies must establish financial responsibility through surety bonds, cash deposits, compulsory insurance or other forms of financial assurance.

Another advantage of financial assurance arises from the fact that liability and responsibility for the clean up and long term maintenance of waste disposal and mine tailings sites become uncertain when operations close, when properties are sold and when companies are liquidated. A site or facility is faced with continuing expenses but with no revenues to cover them. As a result, the costs of clean-up and maintenance responsibilities for some of these facilities have had to be borne by the government. Provision of financial security or assurance at the outset of the operation or the accumulation of a fund over the life of the enterprise will ensure that funds for these activities are available no matter what happens to the original operators or to the ownership of the properties.

Financial assurance is also needed when environmental liabilities are attached to a particular asset such as land. Where contaminated wastes or equipment are deposited or stored at a site, the provision of financial security would enable future owners or, if necessary, the government to undertake clean-up or decontamination expeditiously.

Finally, because the amount of financial assurance that is required usually depends on the expected costs of future clean-up activities, companies and governments are obliged to estimate the cost of these activities. A cost estimation exercise forces firms and government agencies to think seriously about the long term consequences of future activities at the outset of the project and to find least-cost methods or technologies that will satisfy relevant environmental constraints. Otherwise, proponents have no incentive to consider waste site rehabilitation measures until such times as the site capacity has been exhausted. By this time, opportunities for preventative measures may have been lost. Financial assurance requirements can thus spur innovative planning about future environmental protection activities.

Consequently, provision of a financial assurance requirement can provide a potential economic incentive to comply with conditions of an approval or a control order, a source of funds for future clean-up, a guarantee of the availability of funds for compensation and a spur to planning for future environmental protection activities at the outset of the project. Before the

3. ORIGINS OF FINANCIAL ASSURANCE

The financial assurance requirements that are embodied in Part X-A of the recently amended Environmental Protection Act (EPA) have their origins in previous sections of this same statute and in the applications of escrows and surety bonds for other purposes and in other jurisdictions. Three sections in the EPA constitute precedents for Part X-A.

First, Section 34 requires that individuals and firms, but not municipalities, who apply for a certificate of approval for a solid and industrial waste management or disposal operation must

"make a cash deposit, or

"furnish a surety bond, or

"furnish a personal surety."

This security is intended to ensure that sites or haulage systems are operated or maintained according to the requirements of the certificate of approval. Financial assurance can also provide funds for the closure or removal of waste from a site, if required. Section 34 also permitted the "return of any security upon such terms and conditions as the regulations prescribe."12

Until very recently, no regulations were promulgated under this section. However, financial assurance requirements were imposed by conditions on certificates of approval for private waste management and disposal activities under section 38 of the EPA. The specific nature of these requirements was determined on a case by case basis. Although guidelines or policies for specifying the amount or nature of the security required by Section 38 have not been developed, two types of financial assurance have been most frequently used. For example, cash deposits were paid into the "Waste Disposal Sites Trust Fund" set up within the provincial Consolidated Revenue Fund. An irrevocable letter of credit from a proponent's bank is probably the most common form of security that has been provided to satisfy conditions of waste management certificates of approval.

The other precedent, Section 46 of the Ontario EPA, requires that operators of waste disposal wells make payments into the "Waste Well Disposal Security Fund" in the provincial government Consolidated Revenue Fund. These payments are based on the amount and type of waste injected into the well. Four firms are currently making deposits into the Waste Well fund. However, these firm only dispose of brines by deep well injection. Deep well disposal of hazardous industrial waste liquids was progressively restricted and ultimately ceased in Ontario in the early 1970's.

Financial assurance requirements under sections 34, 38 and 46 are concerned only with solid and hazardous industrial waste transport or disposal. There were no requirements to provide assurance in association with control orders or other programs to curtail on-going industrial pollution.

Other legislative precedents for financial assurance may be found in both the U. S. and Canada and in federal and provincial statutes. Perhaps the best known of these statutes in Canada is the federal Nuclear Liability Act. This act is designed to provide compensation for personal injury and property damage caused by nuclear accidents. The Act imposes absolute liability upon the operator of a nuclear facility to compensate for damages arising from a breach of duty to prevent injury to health or property, subject to some specific exceptions. To ensure the availability of compensation funds, the Act requires the operator of a nuclear installation to carry both "basic" and "supplementary" insurance to a combined total of $75 million. Basic insurance is provided by the insurance industry up to a ceiling of $30 million. Supplementary insurance is the difference between the amount of basic insurance and $75 million, and is reinsured by the federal government. Ontario's Pesticides Act also requires all licensed exterminators to carry third party liability insurance.

In the United States, Florida's Oil Spill Prevention and Pollution Control Act requires owners of all terminal facilities and vessels handling petroleum products to provide security in the form of insurance or bonds to insure recovery of costs of oil spill cleanup.

Part XX of the Canada Shipping Act and the U.S. Comprehensive Environmental Response, Compensation and Liability Act (popularly known as the "Superfund") are examples of statutes that provide funds for cleaning up spills and neutralizing abandoned waste disposal sites by requiring companies to pay into a clean-up fund. Ontario's Pits and Quarries Control Act, which is administered by the Ministry of Natural Resources, operates on a different model to ensure that operators rehabilitate worked-out pits and quarries. Regulations require each operator to deposit security with the Ministry of Natural Resources in an amount equal to two cents for every tonne of material removed each year, up to a maximum of $100,000, or $500 per acre, whichever is greater. When rehabilitation has been completed, the operator is entitled to the return of any remaining money. To encourage progressive rehabilitation while the pit is still operating, the operator is entitled to refunds from the security deposits as he carries out rehabilitation.

One of the most far-reaching examples of a financial responsibility requirement is Japan's Health Damage Compensation Law. This statute was passed as a result of devastating

pollution-related disease incidents which occurred in the 1960s and 1970s. To secure the availability of compensation funds, the Japanese legislation establishes a complex system of financing, which includes levies on specific companies and groups of companies, "user" taxes on motorists and funds from general government revenue, the burden of which is distributed among local, regional, and national government.

Prior to drafting the amendment that was to become Part X-A, Ministry staff conducted extensive research on a variety of economic incentive policy instruments both in-house and by means of consultants. The use of these policies in other jurisdictions and their potential application in Ontario were also investigated.

One such study by Peat, Marwick and Partners, which was commissioned by the MOE, identified a variety of limitations associated with the command and control regulatory approach in addition to those noted in section 2 of this paper. For example, existing policies and enforcement tools cannot easily be tailored to respond to economic growth and change or to wide variations in cost and environmental damage conditions which face different sources of the same type of pollutant. Moreover, Peat Marwick and other authorities argue that regulatory initiatives which stress technology-based or simple, across-the-board percent reduction objectives can impose unnecessarily high costs on some polluters. These high costs can generate substantial opposition and non-cooperation among regulated parties.

Four main types of economic incentive policy instruments have been identified and studied by the MOE:

a. emission or effluent charges,

b. tradeable emission rights or entitlements,

c. delay penalties and financial assessments,

d. financial assurance and escrows.

Charge schemes can be designed either to provide an economic incentive to reduce emissions or to generate revenues for communal treatment facilities and abatement programs. All of the charge schemes that are operating in Europe and Japan are intended to generate revenues. The extra-strength sewer surcharge, which is levied in a number of Canadian and U.S. cities, is a form of effluent charge intended to generate revenues to pay the extra costs which industrial wastes may impose on municipal sewage treatment plants. Sims has shown that industrial water users will reduce water consumption and/or install pretreatment of its wastes as a result of changes in surcharges.13

While effluent charges have made little progress in North America, those interested in regulatory reform in the U. S. have focussed on tradeable emission rights and entitlements. Under this approach, a group of emitters of the same pollutant is given an aggregate emission limit together with an apportionment of an initial set of emission or discharge rights to each of the eligible sources. Sources with high abatement costs would be allowed to purchase emission rights from their lower cost counterparts who would reduce their emissions in lieu of the purchaser. The total cost of reducing the aggregate emissions could be lower than technology-based or across-the-board percent reduction objectives because high-cost sources would pay low-cost sources to reduce extra emissions at a lower cost than they could achieve themselves. Controlled trading could also accommodate economic growth in that new sources of a pollutant, whether from a new plant or an expansion of an existing one, could either install best available technology in its own plant or pay another existing source to do so, what ever would be cheaper.

A form of controlled trading called the "off-sets" policy has been implemented in U.S. urban areas where air quality does not meet ambient quality standards and where economic growth would have to be curtailed in order to avoid further deterioration of air quality. This policy has been studied by Canadian provincial and federal governments which found that long range atmospheric mixing of sulphur dioxide (SO2) and the sufficient number of sources would make this pollutant a candidate for a controlled trading system in Canada. Key implementation problems would be the initial distribution of emission rights among sources and transactions costs of implementing a rights scheme could be high.

A third type of economic incentive policy, called a "financial or delay penalty" scheme, is represented by the program that has been enacted in Connecticut. Financial assessments are made against regulated parties in Connecticut when other legal mechanisms are exhausted. While financial assessments have been applied to air, water and solid waste management issues, Connecticut administrators report that assessments have been most successfully applied to failures to submit routine monitoring reports rather than complex industrial pollution abatement programs.

A similar policy instrument, called the "Pollution Control Delay Penalty", was proposed by MOE economists in 1976.[14] This policy would be invoked only when a polluter did not achieve required emissions by agreed-to deadlines specified in orders or certificates of approval. An automatic financial penalty would be calculated on the basis of the difference between target and actual emissions. The penalty would be of a magnitude such that the emitter would find it cheaper to install the pollution

abatement facilities rather than pay the penalty. The scheme was specifically designed to strengthen the current command and control regulatory system. Reliable and agreed-to emissions data as well as abatement cost functions for the relevant plants.

Each of the foregoing policy approaches is being applied in one form or another in different jurisdictions and there are sufficient advantages to each to warrant their serious consideration. Moreover, each policy could be designed to be a component of the existing regulatory system rather than to replace it. Nevertheless, these instruments are perceived by many to be a significant departure from the existing system in Ontario. Moreover, each of these policies would probably give rise to a costly series of legal challenges before they could be implemented.

The Peat Marwick study and other research by MOE staff indicated that an expanded surety bond/financial assurance policy would be the most practical means of incorporating economic incentive qualities into Ontario's environmental regulatory system. Even though a legislative amendment would be required, it would only involve extending a power which the government already had in law. Moreover, surety bonds and financial security requirements are well established business practices and would not be a major departure from current procedures. As noted earlier in this paper, financial assurance guarantees from industrial polluters would forestall the claim that they did not have the funds to complete abatement programs. Furthermore, financial assurance would not impose large extra costs on regulated parties as would a charge scheme. Nor would FA provisions involve complex trading arrangements, information requirements and transaction costs that would be required by a controlled trading program.

It was concluded that an amendment to the Ontario EPA which gave the government the discretionary power to require financial security or assurance in association with approvals and control orders would be the most expeditious and effective means of enhancing the province's environmental regulatory system.

Further research was then carried out to determine the forms of financial security that were being used by other Ontario government agencies and by the private sector. Interviews were held with agency personnel who administered various types of financial security in order to gain a practical perspective on the application of these instruments, especially when the security had to be realized or called in.

Financial security is widely used in Canada and the U.S. to guarantee performance, payments to creditors or taxes, workmanship of products, honesty of employees and contractual agreements. Specific forms of financial security or assurance

include the following:

a. Cash,

b. Surety or performance bonds,

c. Negotiable bonds or securities,

d. Irrevocable letters of credit from a bank,

e. Compulsory insurance,

f. Mortgages or liens.

Of the six types listed, surety/performance bonds are the most prevalent while mortgages and liens are rarely taken.

Surety bonds are used widely in the construction industry to ensure that contractors fulfill their obligations. The Ministry of the Environment requires that all contractors which build MOE-financed water and sewage works provide surety bonds. The company which supplies the surety bond is called the Surety while the person or firm who purchases the bond is called the Principal. The person or entity which receives the guarantee is the Obligee.

Although many insurance companies supply surety bonds, there is a fundamental difference between an insurance policy and a surety bond. Where the insurance company expects to pay on some insurance policies without recovery from the insured, a surety bond is essentially a promise of credit for which no loss is expected. As a rule of thumb, a surety will generally require a principal to have assets valued at least three times the value of the surety bond.

Of the various types of surety bonds available, those used in the construction industry are most relevant to the current problem. In case of a default, money from the surety bond could be used to hire another contractor to finish the job.

The surety bond consists of a performance agreement which specifies the contractual obligations of the principal, the terms and conditions of a default and eventualities which are not covered by the agreement. If a principal defaults on its performance guarantee, the surety company can respond in one of three ways:

a. provide additional financial backing to the principal to enable him to satisfy all obligations,

b. relet the project to another contractor,

c. let the obligee finish the project himself and be reimbursed.

While representatives of the surety industry emphasized that a key factor in granting a surety bond is the indemnification of the principal, it should be noted that this industry has experienced failures in recent years which have left obligees unprotected.

The Ontario Ministry of Consumer and Commercial Relations administers at least seven statutes which require surety bonds for certain kinds of businesses (eg. travel agents and automobile dealers). Some of these statutes, along with their bonding requirements, were enacted as long ago as 1934. Over the past five years, bonding requirements for car dealers and the travel industry have been eliminated in favour of compensation funds. This happened because compensation funds are significantly less costly to administer, payments from "comp" funds are more expeditious and consumer protection would not be compromised by the failure of a bonding company.

These points reflect the experience of the Ministry of the Environment with respect to bonding of construction projects. When a contractor fails, usually because it goes bankrupt during the project, the Ministry has experienced delays and, in some cases, resistance to payment of claims by the bonding company. Some Ministry projects also lost bonding protection when a bonding company failed.

Despite the advantages of compensation funds, the Registrar of the Ontario Consumer Protection Act noted that the government has retained the authority to require surety bonds or other types of financial security as might be needed.

Legislation administered by the Ontario Ministry of Natural Resources gives that agency the authority to require financial assurance for such activities as:

a. mineral exploration, closing and clean-up of mine operations and stabilization or rehabilitation of tailings and closed mines (this provision is now administered by the Ministry of Northern Development and Mines),

b. removal of sand and gravel from crown-owned lands (including submerged lands in the Great Lakes),

c. rehabilitation of gravel pits and quarries,

d. plugging abandoned oil and gas wells and rehabilitating drilling sites,

e. operating concessions in a provincial park.

The Ministry of Natural Resources administers various types of financial securities including cash, irrevocable letters of credit, bank drafts, money orders or travellers' cheques.

An irrevocable letter of credit is an agreement among the principal, the principal's bank and the obligee (eg. the government) which gives the obligee the authority to draw funds from the principal's account or line of credit under the terms and conditions of an agreement. A letter of credit is irrevocable from the point of view of the principal but is issued for a fixed term (normally one year) and a renewal, if required, may not be given if the bank suspects that the principal's financial position has significantly deteriorated. This possibility would have to be offset by requiring the bank to give notice before failing to renew a letter of credit.

Bearer bonds guaranteed by the federal or a provincial government can be used as security. Canada savings bonds would not be eligible as a security because they cannot be transferred to another party by the original purchaser.

Based on the foregoing, the elements and key features of Part X-A were devised and incorporated into an amendment to the EPA, Bill 112. Active development of Part X-A was given momentum when the Liberal government took office in July of 1985. In a speech to the Environmental Law Section of the Canadian Bar Association-Ontario in August, 1985, the new Environment Minister, Jim Bradley, announced:

> "We are considering the possibility of providing for performance bonds or other financial guarantees in some situations as an extra measure of insuring compliance."

He raised this issue again in an address to a Colloquium on the Environment sponsored by the Economic Council of Canada in December of 1985.

Part X-A was added to the Bill 112 on its second reading in December of 1986. Drafting of the financial assurance provisions of Bill 112 took place over some 6 months prior to first reading with some changes made between first and second reading. The financial assurance provisions of Part X-A are specified in section 119a of the Environmental Protection Act. The provisions of Part X-A also applies to the Ontario Water Resources Act.

The key provisions of Part X-A and the issues and questions surrounding its implementation are discussed in the following section.

4. CURRENT PROVISION AND OPERATIONAL GUIDELINES

Part X-A gives a Director (generally a Regional Director or the Director of the Environmental Approvals and Land Use Planning Branch) the authority to require financial assurance to the Crown in right of Ontario for the following:

a. the performance of any action specified in an approval or an order,

b. the provision of alternative water supplies if Ministry staff have reason to believe that communal water supplies might be contaminated by undertakings to which an order or approval is related,

c. Measures to prevent adverse effects that may occur at, or following, closing of an industrial plant or site. (Ont. EPA, s. 119b)

An approval is any certificate of approval under the EPA or the OWRA, except those issued under Part IX of the EPA. An order includes control orders, notices and directives made by a Director under these same statutes.

Seven types of financial assurance can be used:

a. Cash,

b. A letter of credit from a bank and some trust companies,

c. Negotiable securities (bonds) issued or guaranteed by the Government of Ontario or the Government of Canada,

d. A (surety) bond of a guarantee company approved under the Guarantee Companies Securities Act,

e. A personal bond accompanied by collateral security,

f. A bond of a guarantor, other than a guarantee company, accompanied by collateral security,

g. An agreement (with the regulated party),

h. An agreement (with the regulated party) in the form and terms specified by regulations.(Ont. EPA, s. 119a)

The amounts and terms of each type of FA are specified in an approval or an order, except in the case of "h".

Those instruments which have expiry dates must be renewed at least 30 days before they expire. Otherwise, the Director may

4. CURRENT PROVISION AND OPERATIONAL GUIDELINES

Part X-A gives a Director (generally a Regional Director or the Director of the Environmental Approvals and Land Use Planning Branch) the authority to require financial assurance to the Crown in right of Ontario for the following:

a. the performance of any action specified in an approval or an order,

b. the provision of alternative water supplies if Ministry staff have reason to believe that communal water supplies might be contaminated by undertakings to which an order or approval is related,

c. Measures to prevent adverse effects that may occur at, or following, closing of an industrial plant or site. (Ont. EPA, s. 119b)

An approval is any certificate of approval under the EPA or the OWRA, except those issued under Part IX of the EPA. An order includes control orders, notices and directives made by a Director under these same statutes.

Seven types of financial assurance can be used:

a. Cash,

b. A letter of credit from a bank and some trust companies,

c. Negotiable securities (bonds) issued or guaranteed by the Government of Ontario or the Government of Canada,

d. A (surety) bond of a guarantee company approved under the Guarantee Companies Securities Act,

e. A personal bond accompanied by collateral security,

f. A bond of a guarantor, other than a guarantee company, accompanied by collateral security,

g. An agreement (with the regulated party),

h. An agreement (with the regulated party) in the form and terms specified by regulations.(Ont. EPA, s. 119a)

The amounts and terms of each type of FA are specified in an approval or an order, except in the case of "h".

Those instruments which have expiry dates must be renewed at least 30 days before they expire. Otherwise, the Director may

convert the FA into cash to be held as needed for the purposes originally specified (Ont. EPA, s. 119e).

If the Director has "reasonable and probable ground" to believe that the regulated party will not complete any required activity, he may order the activity to be undertaken, by another agency or party if necessary, and use the financial assurance for this purpose. Upon issuing of such an order, the Crown may then convert bonds or other forms of security to cash, enforce a relevant agreement or use any cash that has been provided to carry out and complete the environmental measures specified in the order or approval.

The provisions under Part X-A are entirely discretionary. Moreover, it would be impractical and unnecessary to require FA for each and every order or approval that is issued by the Ministry. Guidelines are, therefore, being prepared to aid Ministry personnel to implement Part X-A efficiently and equitably. These guidelines address a number of procedural questions and issues pertinent to implementation which have been raised by MOE staff. Some of these questions can only be answered by experience or further research. In the remainder of this section, we identify the key implementation questions and note how the Ministry will address them over the next 12 months or so. At the end of 1988, relevant experience and research results will be used to appraise and revise the Guidelines.

It should be noted that, while FA will be required mainly in new orders and approvals, it can also be introduced into existing operations which already have an order or approval in force. Moreover, FA would not normally be required of any public body or institution.

The key questions which the Guidelines attempt to address are:

a. When should FA be required?

b. How should the amount of FA be calculated?

c. When is a regulated party in default?

d. What are the responses to a default?

Since financial assurance has previously been required under Sections 34 and 38 for certain private sector waste management activities, FA will continue to be required for private sector applications for certificates of approval for landfill sites, transfer stations which handle hazardous materials and waste processing facilities which involve the storage of hazardous materials. A financial assurance requirement may be applied to waste haulers (waste management systems), incinerators, PCB

storage sites, transfer stations and organic waste (eg. canning plant wastes) disposal sites, depending on the merits of the case.

It is proposed that financial assurance will also required for approvals under the Ontario Water Resources Act for new mineral milling operations and for private communal sewage or water works which do not have agreements with a local government agency to take them over in the event of default by the original owner. Where it is found that the issuance of a Water Taking Permit under section 20 of the OWRA is likely to reduce the quantity or quality of potable water supplies of the applicant's neighbors, FA should be required.

Some other situations in which FA may be required include:

a. where toxic or hazardous wastes are collected from air pollution control equipment,

b. where a conditional C. of A. is granted for an upgrading of an air pollution control facility and there is uncertainty how well the new equipment will work,

c. approvals for septage holding lagoons and private communal sewage systems,

d. when long-term and/or perpetual management, monitoring and care of a storage or disposal site is required,

e. where there is reason to expect that a regulated party might become insolvent in the future.

Most of these circumstances involve FA as a condition of a certificate of approval. However, FA may also be included as a condition of an order when the regulated party meets one or more of the following conditions:

a. There has be a conviction for a violation involving the same pollution problems that are being addressed in the current order.

b. Deadlines have been missed in the past.

c. An extension to a compliance deadline has been requested and granted.

The form and amount of financial assurance required will depend on the nature of the potentially polluting activity keeping in mind the financial burden being placed on the regulated party.

In most instances, the amount of financial assurance

required will be based on the estimated capital and/or operating costs of each abatement, environmental protection or clean up activity that is required in the order or approval. C. of A. applicants or recipients of an order will be asked to provide these estimates in the first instance. In addition, procedures and formulae to aid MOE personnel in estimating the required amount of FA are being prepared for inclusion in the Guidelines. Moreover, where an order or approval indicates that there are several acceptable techniques or methods to achieve the specified environmental objectives, the amount of FA can be based on the least-cost approach or technology.

It is expected that there will be considerable flexibility in the design of FA arrangements, although standardized forms are being prepared for some instruments. If, for example, a program is to be phased over 3 or more years, the amount of FA required may be reduced as the projects are completed. Moreover, if FA is required for future decommissioning, rehabilitation or perpetual care, FA may be accumulated over time by interest earned and/or by annual payments.

An information system is also being developed to facilitate periodic review of the FA provision and the expected costs of the environmental regulatory activities in order to ensure that adequate funds are, and will be, available. Moreover, given the recent instabilities in financial institutions over the past several years, it will also be necessary to monitor the solvency of those who provide financial assurance.

The use of bearer bonds and other debt instruments (including stripped bonds) which fluctuate in value according to economic conditions could impose substantial administration costs since these instruments would have to be monitored rather frequently to ensure that there is sufficient FA available.

Conditions of a default will be specified in the relevant approvals and orders. For example, any violation of any order, approval, regulation or statute may be specified as a default. Defaults could also be defined as missing two successive deadlines in a compliance schedule. Another possible condition of a default could be defined as providing no evidence that steps are in progress, within half the time alloted for implementation of the required activities, to comply with an order or approval.

Even before a default is declared, it may be necessary to convert documentary (non-cash) assurance (eg. letters of credit, surety bonds, agreements, etc.) to cash when notice or evidence is received that the instrument will be cancelled or that either the regulated party or the guarantor will soon become insolvent.

When a default occurs and the Ministry has presumably converted the assurance to cash, the primary objective of the

Ministry's actions will be to implement the specified regulatory actions. This may include hiring a contractor to carry out or complete the required works. As noted the Director may issue an order (under section 119f(1) of the Ont. EPA) which requires that specific environmental measures be implemented and the FA be used to pay for it.

For activities and projects which can be completed by outside contractors, such as rehabilitation of mine tailings sites, clean up of contaminated materials, the operation of communal sewage or water works, implementation of the order using the FA funds seems to be straight forward and without complications. However, where an industrial abatement program involving complex manufacturing plant and processes is concerned, it may not be feasible to hire an outside contractor to install abatement equipment or complete process changes. The feasible responses to a default involving an abatement system at a manufacturing plant would appear, at this time, to be prosecution as warranted and to withhold the FA until the project is completed.

A review of the experience with the application of FA to date can provide insights concerning how to handle defaults. This issue is addressed in the next section together with a discussion of the potential economic effects of applying FA.

5. APPLICATIONS OF FINANCIAL ASSURANCE TO DATE

Financial assurance requirements have, so far, been applied primarily to privately owned or operated waste sites or waste management systems (ie. haulers) under the authority of sections 34 and 38 of the EPA. As of September 1987, 21 firms have some sort of financial assurance posted with the Ministry of the Environment. Of these, approximately 13 have been required as conditions of certificates of approval, four on the basis of section 34, two as a result of control orders and the remainder through individual agreements.

Letters of credit from the applicants' banks are by far the most prevalent instruments of assurance used. Eighteen of the 21 firms which furnish assurance have provided 23 letters of credit for their operations with several firms having more than one letter of credit on record.

Of the 23 active letters of credit held by the MOE, 15 pertain to waste disposal sites, four to waste management systems, one to the storage of PCB's, one to the storage of wastes and one to a waste removal operation. One additional "letter of credit" which is actually a cash deposit agreement for the rehabilitation of an asbestos contaminated industrial property. The amounts of the currently active letters of credit range from \$7,300 to \$2,500.000. The mean value is \$257,840 with a median of \$61,541 for 23 entries.

Another 11 letters of credit on record have expired. The projects, facilities or activities associated with these instruments have been completed or are no longer in operation.

Cash deposits are the only other form of FA currently in use. Cash deposits are usually made into a trust fund held within the provincial Consolidated Revenue Fund. For example, four firms are currently making cash deposits to the "Waste Well Disposal Security Fund" (for the disposal of brines in the Sarnia area) as required by section 46 of the EPA. As of Sept. 30, 1987, this fund had a balance of \$604,574. To date, no payments have been made from this Fund.

Another example is the "Waste Disposal Site Trust Fund", which was established under authority of section 34 and currently has a balance of \$36,215. This entire balance is attributed to one firm. Another \$17,193 had been deposited by a second company. However, this amount has recently been paid to the receivers of the contributing company which apparently has gone bankrupt. There is no record of any compensatory payments from this Fund.

Each of the 23 letters of credit on file was drawn up on an ad hoc basis. In some cases, standard forms from the banks were

used and modified slightly. In others, MOE solicitors drew up specific agreements. As shown in Appendix A, standardized agreement forms are being prepared for future FA agreements.

There are few instances where financial assurance has been required as part of a control order for an industrial abatement program. There is, however, one example of a voluntary application of a financial assurance provision to a control order aimed at controlling industrial pollution. In 1974, the Ministry of the Environment struck an agreement with Cyanamid of Canada concerning the installation of air pollution control equipment at its Welland, Ontario, plant. Cyanamid agreed to deposit $1.5 million with the Royal Bank of Canada in an account under the control of the Ministry of the Environment as a surety bond from which the company recovered funds in periodic payments as the facilities were completed. The program was finished on time as well.

A financial assurance requirement was included in a control order that was recently issued to the Domtar pulp and paper mill in Corwall, Ont. However, the company has appealed a number of the provisions in the order, including the financial assurance provision. At this writing, the appeal has not been yet been heard.

Other applications to date have been limited to waste disposal sites for which financial assurance is required as a condition of the certificate of approval; in only one case has financial assurance been required by a control order. Letters of credit are by far the most frequently used instrument with some cash deposits to the two Trust Funds noted earlier.

It is intended to apply FA provisions to a wider range of private sector activities and Ministry regulatory actions.
The added costs of a more frequent application of FA are of concern to a number of people. A priori analysis would indicate, however, that these cost impacts will be small. For example, the costs to the contributor of cash security will be offset by interest earned. Hence, the cost of depositing funds into a financial assurance account would be the difference between what is being paid in interest by the Provincial Treasury and the return (eg. profit) that could be made on these funds in another use.

Where cash is being collected and accumulated over a long time period, eg. 15 - 25 years, for waste site rehabilitation or closeout, firms are likely to become more concerned about these opportunity costs because these funds will be permanently unavailable to them.

Banks charge a standard fee for letters of credit. This annual fee currently amounts to about $10 per $1,000 of the value

of the guarantee, or about 1% of the total amount of the guarantee, usually with a minimum charge of $50. For large customers, a bank could charge as little as $5 per $1,000. Letters of credit normally stand for one year or less and must be renewed.

Premiums or fees paid for surety bonds are about $15 per $1,000 per year or 1.5% of the amount of the guarantee. Thus, a surety bond for $1 million would cost $15,000 per year to maintain. In addition, a firm is usually expected to have assets or collateral sufficient to cover the value of the bond.

The costs associated with the use of Government of Ontario or Canada bonds is similar to that of cash. The owner of the bonds continues to receive the return or interest but the liquidity of the bonds has been eliminated.

The cost implications of a financial assurance requirement of $100,000 which would be needed in 10 years depend on the instrument chosen. A cash deposit of the full $100,000 would involve the loss of the return that could be made on this amount less the interest paid by the Provincial Savings Bank (about 5 or 6% per annum). The difference could be considerable under favorable economic conditions. However, if the $100,000 were not needed until 10 years hence, it would be necessary to deposit only $53,273 at the outset; at an interest rate of 6.5% per year, the fund would accumulate to $100,000 in ten years. Alternatively, the regulated party could deposit $7,410 per year over 10 years to accumulate the $100,000.

The implications for using bonds are similar to those if cash were involved. At prevailing interest rates, the firm would have to purchase about $50,000 in bonds which would accumulate to $100,000 in 10 years. Similarly, the proponent could deposit about $7,500 per year in bonds to make up $100,000 in 10 years. There might be some slight tax advantage in using bonds as security.

A letter of credit from a bank would cost about $1,000 per year depending on the firm's rating as a client. Over ten years, this could amount to as much as $10,000 in fees.

A surety bond worth $100,000 would cost approximately $1,500 per year. Over 10 years, this would amount to $15,000 although the value of future payments would be discounted appropriately.

The letter of credit and the surety bond would involve the lowest cash outlay but would be a pure cost to the principal. Using cash or bonds would tie up much larger amounts of funds. Even the amount of a letter of credit is said to be regarded by some institutions as a debit against the firm's assets.

Financial assurance requirements could stand as a barrier to entry for some businesses and entrepreneurs. However, given the range of non-cash instruments available, it is likely that security could be designed so as to mitigate this consequence. This point is, nevertheless, a topic for further investigation.

6. CONCLUSIONS AND FUTURE RESEARCH

The financial assurance provisions of Part X-A of the Ontario Environmental Protection Act appear to be unique in North American environmental legislation. It was enacted to enhance the enforcement capabilities of the Ontario Ministry of the Environment and to ensure that funds are made available to implement abatement, environmental protection and future clean-up and rehabilitation were this is necessary.

Several key implementation questions will be addressed over the next year or so by means of a carefully considered implementation program and by research. Implementation Guidelines are being prepared to facilitate this program.

Because the requirement for financial assurance is discretionary, criteria and conditions must be established which will guide the decision to require financial security. Procedures for determining the value of FA required are currently being developed although certificate of approval applicants and recipients of orders will be asked for this information as well. Conditions which constitute a default are being defined but will have to be tested in actual orders and approvals. Finally, experience in dealing with default situations, especially those where FA is obtained for complex air or water pollution abatement programs will be evaluated as such situations arise.

Another important implementation question is the extent to which firms and other regulated parties will appeal FA conditions in orders or approvals.

Finally, implementation of the financial assurance provisions will necessitate a greater degree of monitoring and follow-up on progress. Monitoring of the financial capabilities of principals (banks and surety companies who give security) and certain financial institutions which provide guarantees will be necessary. The Ministry of Financial Institutions will be an important source of information for that purpose.

Several research questions or topics were identified in the course of this investigation. First of all, how various types of regulated parties perceive their risk of potential prosecution and expected loss as compared with the actual statistical experience of having a violation detected, prosecuted, convicted and fined would be a subject of interest.

Studies will be required over time to verify the relevant cost estimating procedures and to generate the computational algorithms, data and technical coefficients needed to produce estimates.

The extent to which FA requirements become a barrier to entry in manufacturing and in the waste management and disposal field should also be investigated.

Finally, investigations concerning the effectiveness of FA requirements at inducing desireable environmental behaviour as compared with similar regulatory activities without FA would undoubtedly be enlightening. The challenge for this type of work will be to define appropriate measures of compliance and accomplishment as well as suitable comparable, or control, situations.

It will be some time before we can judge the true impact of the financial assurance provisions in Part X-A on Ontario's environmental protection efforts and on the regulated individuals and firms who are subject to these provisions. However, we are confidant that this component of the act can be implemented in an equitable manner with minimal economic disruptions for those involved.

REFERENCES AND FOOTNOTES

(1) Bill 112, An Act respecting the Enforcement of Statutes related to the Environment, 2nd Session, 33rd Legislature, Ontario, 35 Elizabeth II, 1986.

(2) The steps that must be taken to initiate and prepare a control order or a program approval for an industrial pollution situation are found in Policy 05 of the Manual of Environmental Policies, Toronto: Ontario Ministry of the Environment.

(3) Control orders are authorized under section 6 and Part X of the Ontario Environmental Protection Act, Revised Statues of Ontario, 1980, Chapter 141. An equivalent instrument, the "Requirement and Direction" is authorized by the Ontario Water Resources Act.

(4) The Environmental Protection Act and the Ontario Water Resources Act authorize a Ministry Director to issue a stop order in writing with written reasons and without prior written consent of the court. The recipient of a stop order is to comply with the order immediately. A stop order is to be used where there is a presumed danger to life and health from the proscribed activity.

Stop orders have been used infrequently in the following cases: Canada Metals of Toronto, Rockcliffe Park Realty of Ottawa and a Mr. Heddon of Stratford, Ont.

Section 144 of the EPA provides a power to "restrain by action" which is equivalent to a court injuction.

(5) For example, the maximum fine for a corporation that is convicted of offences involving hauled industrial liquid wastes or hazardous wastes has been increased from $100,000 per charge to $500,000 per charge (Ont. EPA, s. 147).

(6) Ontario, Ministry of Treasury and Economics, Ontario Statistics 1986, Toronto: Sectoral and Regional Policy Branch, Ministry of Treasury and Economics, 1986, p. 792.

(7) For example, the number of occasions each year in which the Air Quality Index or ambient air quality guidelines for certain contaminants have been exceeded are declining in most areas of the province. See Ontario Statistics 1986. Ibid., p. 797. Moreover, between 1964 and 1979, only 8 water quality monitoring stations have evidence deteriorating water quality while 65 have shown steady improvement. See Ontario Statistics 1986. Ibid, p. 799.

(8) Expenditures on pollution control equipment, supplies and services give rise to economic activity, jobs and income. However, the fact of their existence does not necessarily lead to greater overall productivity in the economy, nor to higher total output or employment. Environmental expenditures would have been spent on other goods and services if not mandated by regulation. The extent to which socity is better off with environmental regulation is measured by difference between the value of the opportunity costs of pollution control that are foregone and the value of the environmental benefits that are gained from the regulatory efforts. See U.S. Congress, Congressional Budget Office, Environmental Regulation and Economic Efficiency. Washington, D. C.: Congressional Budget Office, March 1985, p. 5.

(9) See Monica E. Campbell and William H. Glenn, Profit From Pollution Prevention: A Guide to Industrial Waste Reduction and Recycling. Toronto: Pollution Probe Foundation, 1982.

(10) Peat, Marwick and Partners in association with W. A. Sims, Economic Incentive Policy Instruments to Implement Pollution Control Objectives in Ontario. A report prepared for the Ontario Ministry of the Environment, Toronto, July 1983, pp. II-9, II-10; Brian E. Felske. Sulphur Dioxide Regulation and the Canadian Non-Ferrous Metals Industry. Technical Report No. 3, Ottawa: Economic Council of Canada, Jan. 1981; Peter A. Victor and T. N. Burrell, Environmental Protection Regulation: Water Pollution and the Pulp and Paper Industry. Technical Report No. 14. Ottawa: Economic Council of Canada, August 1981.

(11) This argument is further developed in Peat, Marwick and Partners, op. cit., pp. II-10 - II-12.

(12) A requirement to post security was recently imposed on operators of PCB destruction facilities by means of section 8, Ontario Regulation 148/86.

(13) W. A. Sims, "The Response of Firms to Pollution Charges," Canadian Journal of Economics, 12, 1979, pp. 57-74.

(14) J. A. Donnan and P. A. Victor. Alternative Policies for Pollution Abatement: The Ontario Pulp and Paper Industry. Vol. III - Summary and Update. Toronto: Ontario Ministry of the Environment, 1976.

DISPOSAL OF FORMATION FLUIDS BY
OIL PRODUCERS IN
PETROLIA, ONTARIO

AN ENVIRONMENTAL-ECONOMIC ASSESSMENT

by

Michael F. Goodchild
Department of Geography
University of Western Ontario
London, Ontario

and

Jack A. Donnan
Policy and Planning Branch
Ontario Ministry of the Environment
Toronto, Ontario

A paper to be presented at the 1987 Annual Technology Transfer Conference, November 30, 1987

October 1987

NOTICE

The primary thrust of this paper is to demonstrate methodology. The information presented in this paper comprises a substantive portion of a draft report presently under review by the Ontario Ministries of Environment and Natural Resources and the petroleum producers in the Petrolia area. The opinions, conclusions and suggestions found in this paper are those of the authors and do not necessarily represent those of the Ontario government or the Petrolia oil producers.

1.0 INTRODUCTION

Oil deposits in southwestern Ontario have been tapped since the beginning of the North American oil industry. The oil pools that are located beneath Oil Springs and Petrolia, Ontario were discovered in 1858 and 1862 respectively (Habib and Trevail, 1984: 22) and they may have the longest continuous record of production of any on the continent. Indeed, the town names, Oil Springs and Petrolia, evoke the heritage that oil holds for the people of the region. While the major petro-chemical complex at Sarnia, Ontario owes its existence to the early development of oil production in the area, the petroleum industry has long outgrown its origins in and around Petrolia and Oil Springs.

Oil wells in southwestern Ontario produce varying amounts of "formation fluid" along with the crude. Formation fluid is a dilute salty water with a specific gravity of approximately 1.02, which is about one-third as salty as sea water. This fluid is called "brine", although it is not the same as a saturated solution of sodium chloride, and often contains hydrogen sulfide, ammonia and small amounts of residual hydrocarbons, particularly heavy paraffin wax fractions.

The oil-brine mixture is pumped to the surface, where it is separated by gravity in tanks. The oil floats to the top while the brine is drained into holding ponds or, in some instances, directly into area watercourses. The oil is collected by truck and taken to a "bulk plant" in Sarnia owned by the shipper. From this bulk plant, the oil is pumped directly to the Imperial Oil refinery in Sarnia.

Even though cattle reputedly drink the brine fluids without ill-effect, bio-chemical surveys of watercourses in and around Petrolia during 1976, 1979 and 1981 have shown that water quality has suffered impairment in certain streams and that brine discharges are, in some cases, responsible for violations of provincial water quality criteria (Wood, undated). In addition, people in the area have complained about sulphurous odours in stream beds.

In 1984, Ministry of the Environment officials advised Petrolia area oil producers that more environmentally desirable methods of brine disposal would have to be adopted and that the practice of discharging formation fluids into streams would have to come to an end. The Ministry of Natural Resources is involved in this regulatory effort because it is responsible for regulating oil exploration,

well drilling, oil production and the subsurface disposal of certain liquid wastes.

In response to this directive, Petrolia producers met with Ministry officials to examine methods of brine disposal that would be environmentally acceptable. They concluded that injection into a porous rock layer below the oil-producing formation was the most practicable method consistent with environmental objectives (Petrolia Oil Producers' Investigation Committee, undated).

However, producers voiced concerns about the economic repercussions of a brine disposal program. Some claimed that the extra costs of installing a disposal well would very likely force them to suspend their operations. Because of these concerns and because the oil production operations in and around Petrolia are part of Ontario's heritage, it was recognized by the Ministry of the Environment that careful attention would have to be paid to the economic disruptions that might result from a precipitous brine disposal program.

Consequently, the Ministries of the Environment and Natural Resources commissioned the authors to:

- estimate the potential costs of a deep well brine disposal program;

- determine the distribution of these costs among producers and assess the economic effects on these operations;

- provide recommendations regarding the elements of, and a timetable for, implementing a program for brine disposal;

- comment on other implications that might be revealed.

A customized "location-allocation" model was developed to evaluate disposal options and identify the least-cost brine transport and disposal systems. The model was used to compute the number and location of centralized brine disposal facilities for Petrolia producers which would minimize the sum of transportation and construction costs, given specific assumptions and input data.

The results of this application of the model and an assessment of the potential economic effects of the brine disposal costs on producers are presented in a report by the Ontario Ministry of the Environment (1987). A single set of

estimated costs, equipment life and operational characteristics were used in that particular application. Some of these input values (called "default" values) were uncertain and it was not known what magnitude of change in these values would affect model results and the distribution of disposal costs.

In the present paper, the results of the initial Ontario (1987) study which used the "default values" in the location-allocation model are presented. In addition, a sensitivity analysis is carried out in which the most uncertain variables are systematically raised or lowered, within theoretical and empirical reason, and the results of model applications are compared.

In the following section, the physical dimensions of the petroleum industry in the Petrolia area are described together with selected parameters of the pollution problem. Brine disposal technologies that were investigated are detailed in section 3. The brine disposal system designs that will be analyzed with the model are also specified.

Elements of the location-allocation model are presented in section 4. Input data are discussed and so called "default values" for each of the model variables are specified. Areas of uncertainty are also noted.

Results of the location-allocation optimization procedure using the default values are presented in section 5. The sensitivity analysis strategies are defined in this section and the results of model applications using these alternative values are presented and compared.

The economic implications of a brine disposal program on Petrolia producers are discussed in section 6. The implications of the sensitivity analysis results for program design are noted where relevant.

Concluding remarks are presented in section 7 along with suggestions for further work in this area.

2.0 OIL PRODUCTION AND BRINE DISPOSAL IN THE PETROLIA OIL POOL

Annual and cumulative oil production figures from 1863 to 1986 are shown in Figure 2.1. Annual petroleum production from all of Ontario peaked at 210,464 cubic meters (m^3) or about 1,323,800 imperial barrels in 1966 (Habib and Trevail, 1984: 20).[1] Oil production declined steadily until 1982 when it reached 85,637 m^3 or 538,657 imperial barrels. Annual oil production in Ontario is now growing again. Total oil production in 1984 amounted to 90,344 m^3 and it reached 135,816 m^3 in 1986 (Trevail, 1987).

The Imperial Oil Ltd. (IOL) refinery in Sarnia, where all of the petroleum produced in Ontario is processed, has a daily refinery capacity of 21,500 m^3 per day or about 7 million m^3 per year. Total oil production from all of Ontario's oil wells during 1986 amounted to 135,816 m^3 per year or 2% of the annual capacity of the IOL refinery.

Hydrocarbon deposits (oil and gas) are entrapped in each of the four major stratographical or geological layers found in southwestern Ontario: the Devonian, Silurian, Ordovician and Cambrian. About 39% of the total annual Ontario oil production in 1983 came from Devonian deposits (Habib and Trevail, 1984: 22). Devonian petroleum deposits are relatively shallow, ranging from 30 to 160 metres (90 to 480 feet) in depth. Silurian deposits, which account for another 41% of Ontario's annual oil production, are found at depths of 300 to 800 metres or 900 to 2,400 feet (Habib and Trevail, 1984: 22-23).

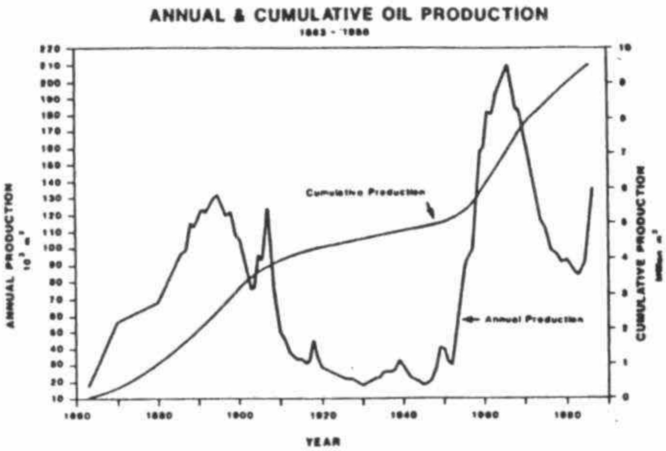
Since 1858, twenty-five oil pools or fields have been discovered in the Devonian deposits in southern Ontario (Bailey Geological Services, Ltd., 1985: 77). Only seven of these pools are still in production, although five have accounted for 98.6% of the total cumulative oil production from the Devonian deposits. Three of the seven active pools - Petrolia, Oil Springs and Rodney - account for more than 88% of the oil taken from Devonian deposits. The distribution of production from the major Devonian pools, as of December 31, 1981, is shown in Table 2.1.

The focus of the present study is the Devonian oil deposits of the Petrolia oil field. Between 1978 and 1985, total production in the Petrolia field doubled, from 3,322 m^3 in 1978 to 6,619 m^3 in 1985. The field now accounts for almost 10% of Ontario's total annual oil production. Even though oil prices fell during 1986, the Petrolia field is likely to see continued increases in the numbers of

---

[1]One cubic metre, (m^3) = 6.29 imperial barrels.

FIGURE 2.1



SOURCE: Petroleum Resources Section, Ontario Ministry of Natural Resources, London, Ont.

TABLE 2.1

Oil Production from Devonian Oil Pools in Southern Ontario

Source/Pool	Annual Output for 1982		Cumulative Production as of Dec. 31, 1981	
	(m^3)	(%)	(m^3)	(%)
Total for Ontario	85,637.3	-	9,149,624.1*	
Total for Devonian Pools	33,753.5	100.0	6,373,680.5	100.0
Petrolia	5,445.4	16.1	2,760,287.0	43.31
Oil Springs	5,660.3	16.8	1,478,815.0	23.20
Rodney	20,788.5	61.2	1,375,092.0	21.51
Bothwell-Thamesville	1,520.6	4.5	498,414.0	7.82
Glencoe	293.5	0.9	171,841.0	2.70
Sub-total	33,708.3	99.5	6,284,449.0	98.54

*As of December 31, 1982

Sources:

Annual output: Habib, A.E. and Trevail, R.A. (1984: 20,22).

Cumulative Production: Bailey Geological Services Ltd. and Robert O. Cochrane. (1985: 45).

producers, wells and production. Recent lower oil prices are still substantially higher than oil prices which prevailed prior to 1973.

Despite the long period of production from the Petrolia field, it is estimated that no more than 20% of the available oil has been extracted so far. At current rates of extraction, production could continue well into the next century. Depletion of the field is not, therefore, a factor over the time horizon relevant to this investigation.

Refinery records identify producers who ship crude oil to the IOL refinery. In 1985, there were 17 active producers, all located within a 5 Km radius of the centre of Petrolia. The names of the producers are listed in Table 2.2 while their locations are shown in Figure 2.2. The larger, successful Petrolia producers operate up to 30 wells. Each well produces only about 1 barrel of oil per day or about 500 m^3 per year from a 30 well operation.

Of the 17 producers operating in 1985, five produce over 500 m^3 of oil per year and can be considered "large". Revenues for each of the five largest producers during 1985, which accounted for 66% of total revenues in that year, ranged from $145,000 to $250,000. Larger producers generally hire one or two full-time employees. One producer estimated that oil producers employ between 20 and 30 people full-time in Petrolia.

The oil produced from Petrolia and other nearby oil fields is collected by trucks operated by Harold Marcus Ltd. of Sarnia. The oil is delivered to a bulk plant owned by Marcus. From the bulk plant, the oil is then pumped directly to the Imperial Oil refinery as it is needed.

Prices from Petrolia and from other Ontario oil fields are set by Imperial Oil and are based on world reference prices. Prices paid for Petrolia crude are graphed for 1985 and 1986 in Figures 2.3 and 2.4. These graphs show that the price of Petrolia crude remained at $191.89/$m^3$ between January 1, 1983 and June 1, 1985. The price then rose to $236.80/$m^3$ during the summer of 1985, but then fell slightly to $229.32/$m^3$ by the fall of 1985. Oil prices fell precipitously in 1986, following the decline in world oil prices. By September 1986, prices had fallen to $118.57/$m^3$ (about $18.85 per barrel).

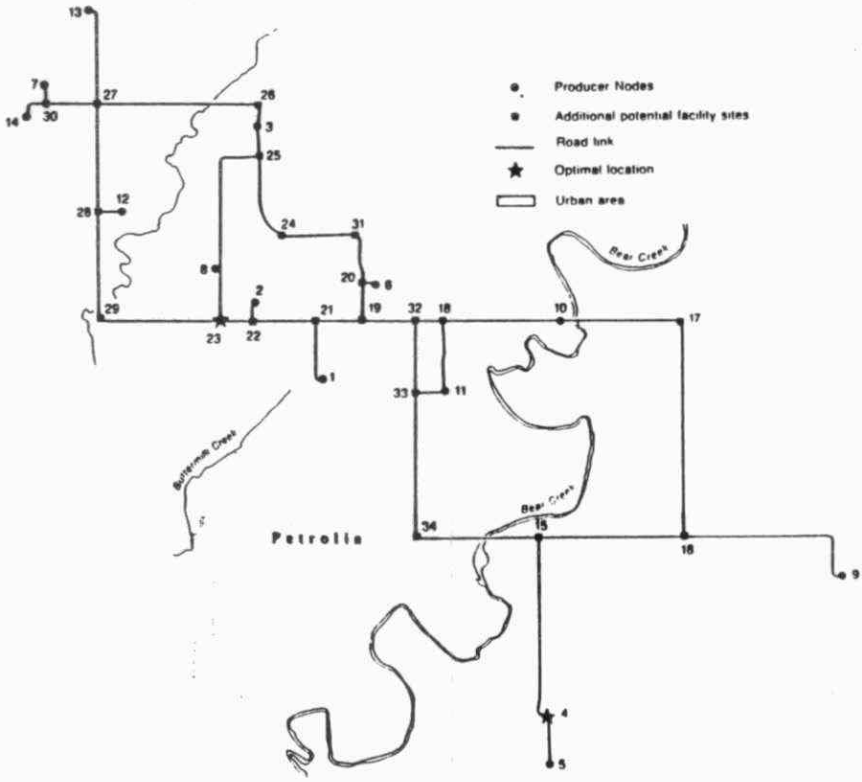
TABLE 2.2

Oil Producers and Operators in the Petrolia Oil Field (MNR #12) as of January 6, 1986

No.	Operator/Address	MNR #	Imp. Oil Prod. No.	Tender No.	Property Location/ Description Con.	Lot	Number of Operating Wells (1984)
1	Mr. Roy Ayrheart Blind Line P.O. Box 595 Petrolia, Ont. N0N 1R0	048	116	T.448	11	12 (Wells Property)	4
2	Orval & Irene Ayrheart P.O. Box 595 Petrolia, Ont. N0N 1R0	044	110	T.299	12	11 (E½)	12
3	Bear Creek Resources Ltd. c/o Mr. B. Govreau-ABC Managers Ltd. 2 Thorncliffe Park Drive Unit 51 Toronto, Ontario M4H 1H2	008	139	T.446 A.553	12 12	11 12	11 15
4	Harold Bender 184 Adelaide St. Strathroy, Ontario N7G 2V5	007	122	A.001 T.550	10 9 12	14) 14) 15 A&E Range Well #2	12 1
5	Walter Brand P.O. Box 1100 Petrolia, Ontario N0N 1R0	051	135	T.300	9	14 (Copeland Prop.)	11
6	Canflow Services 373 South Vidal Street Suite A Sarnia, Ontario N7T 2V3	130	144	T.606 T.603	12 12	12 Enniskillen 12 (E ½ Lot)	-
7	Cartier Resources Inc. 111 Richmond Street W. Toronto, Ontario M5H 2G4	054	149	A.540	13 12	8, 9 7	4
8	Mrs. Ruth A. Edward P.O. Box 125 Petrolia, Ontario N0N 1R0	068	183	T.502	12	11 (Edward Property)	24
9	Mr. Willis K. Jacques 4075 Petrolia Street P.O. Box 778 Petolia, Ontario N0N 1R0	076	261	T.271	10	17 (Jacques Enniskillen)	18
10	William C. Noble General Delivery Oil City, Ontario N0N 1R0	133	365	T.619	12	14,15	7
11	Petrolia Discovery Foundation Inc. P.O. Box 1480 Petrolia, Ontario N0N 1R0	005	417	T.506	11	13 (Bradley Property)	9
12	Mrs. Dorothy Stevenson P.O. Box 91 Petrolia, Ontario N0N 1R0	110	465	-	12	10	21
13	Frank Vye R.R. #1 Brigden, Ontario N0N 1B0	-	540	T.575	13	9	-
14	Gordon Williams P.O. Box 298 Corunna, Ontario N0N 1G0	-	547	A.562	12	9	6
15	Murray Bradley 4422 North Street Petrolia, Ontario N0N 1R0	-	121	T.661	Bradley Property Noble Well		-
16	Lyons Wilson & Baines P.O. Box 1130 Petrolia, Ontario N0N 1R0	-	167	T.654	Petrolia Well		-
17	625138 Ontario Limited c/o Mr. Owen Gray P.O. Box 903, Sarnia, Ontario N7T 7J9	-	367	T.651	Tank Street Well		-

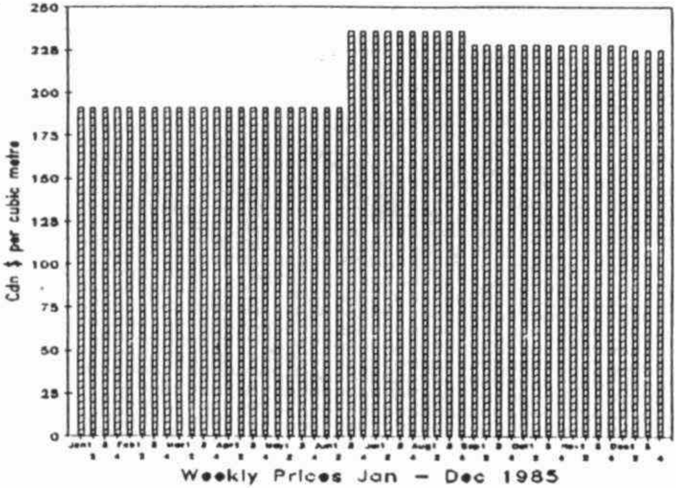
Source: "Ontario Crude System - Master List", Imperial Oil Co., Jan. 6, 1986

FIGURE 2.2
TOWN OF PETROLIA SHOWING LOCATIONS OF OIL PRODUCERS, TRANSPORT LINKS AND OPTIMAL DISPOSAL SITES



Optimal disposal site locations are based on Default Values for model parameters.

Prices for Petrolia Field (#12) Crude 1985



Prices for Petrolia Field (#12) Crude 1986

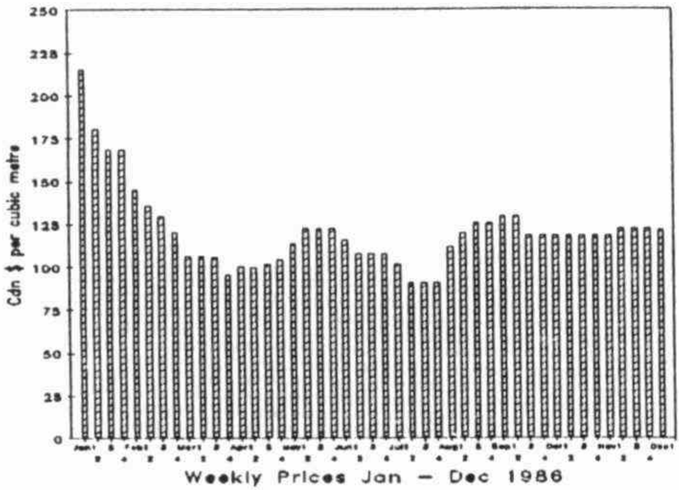


TABLE 2.3

Pollution Sources to Four Watercourses in the Petrolia Area

Watercourse	Producer	Brine Discharges (L/day)	Treatment Activity/Notes	Other Potential Sources of Pollution
Stonehouse Drain	1. Bear Creek Resources	40,000	Lagoons	1. Farm drainage 2. Storm drains 3. Septic tanks
	2. Orval Ayrheart	60,000	Shallow pond	
	3. Edward Estate	90,000	Lagoons (op. by O. Ayrheart) - oxidize H_2S - separate residual oil - precip. sulphides	
Buttermilk Creek	1. Bear Creek Resources		Disposal well installed	
	2. R. Ayrheart	4,500		
Durham Creek	1. Walter Brand	20,000	Brine is discharged onto land and does not reach creek as surface runoff	
Bear Creek	1. Petrolia Discovery Foundation		Aerated lagoon	1. Poultry operation 2. Petrolia Sewage Treatment Plant 3. Storm drainage 4. Septic tanks N.B. Below Petrolia, Bear Creek ultimately receives brine from most producers.
	2. P & E Oil Recyclers (Canflo Res.)	40,000		

Source: T.E. Wood (undated). "An Assessment of the Impact of Devonian Oil Production in the Environment in the Petrolia Area". (Unpublished manuscript).

At a price of \$191.89 per m^3, total revenue for producers was \$1.2 million in 1984. Total revenue for 1985 amounted to \$1.4 million. The average price during 1985 was \$216 per m^3, slightly higher than during 1984.

Even though oil prices have dropped from the high levels enjoyed during the early 1980's, current prices of \$18-\$19 per barrel are still substantially higher than the \$5-\$8 per barrel that prevailed prior to 1973. Oil extraction from the Petrolia and other Devonian Pools continues to be an attractive venture to many people.

One operator, Petrolia Discovery Foundation, is a municipally-sponsored, non-profit organization. Buildings and pumping equipment are over 100 years old and the operation is set up as a museum. Revenues from visitors are reported to account for approximately 20% of the Foundation's total revenue.

Because thousands of wells have been drilled into various hydrocarbon formations over the past 125 years, gas pressure has dissipated. In order to extract oil, a well shaft is sunk to the oil-bearing strata. A mixture of oil and brine seeps into the bottom of the shaft and this mixture is then pumped to the surface. The brine actually facilitates oil production because the oil-brine suspension flows into the wells much faster and can be pumped more easily.

The ratio of brine to oil varies substantially from well to well and between operators. Figures given by two operators on Ministry of Natural Resources registration forms indicate ratios of 40:1 and 100:1. Verbally reported brine flow rates from four operators indicated ratios of 15:1, 35:1, 40:1 and 20:1. A 20:1 brine-to-oil ratio was judged to be a reasonable "average" figure for estimating brine production and the costs of disposal. Using the total 1984 oil production from the Petrolia field, 6,276 m^3, the 20:1 ratio yields an estimate of 125,500 m^3 brine per year from the Petrolia field.

Most of this fluid is discharged into area watercourses such as Bear Creek, Stonehouse Drain or Buttermilk Creek, so named because the water often has a whitish milky colour.

Any systematic assessment of the environmental effects and damages caused by the brine would involve:

(1) an identification and quantification of brine discharges;

(2) a determination of the ecological effects of brine, including changes in ambient quality parameters; and

(3) an assessment of the significance of the ecological effects on people.

A summary of pollution sources, including oil wells, on Bear Creek, Durham Creek, Buttermilk Creek and Stonehouse Drain is shown in Table 2.3. In addition to oil field brine, the Petrolia sewage treatment plant, storm drainage, agricultural drains and a poultry farm have been identified as pollution sources to Bear Creek. As indicated earlier, formation fluids are the source of excessive chlorides, hydrogen sulphides, ammonia and small amounts of oil globuals, all of which can impair the water quality of the four water-courses noted in Table 2.3.

Water pollution may affect people directly if pathogens cause disease and illness. However, most adverse effects of water pollution on people occur as a result of environmental or ecological changes which, in turn, cause damages or discomfort to people. Some adverse ecological effects may not have any discernable impacts on human well-being.

Wood (undated), writing in 1980-81, notes that chloride levels in the Stonehouse Drain reached 3,300 mg/L, water was very turbid and that discharges of brine water and oil wastes severely impaired sections of the Drain (Wood, p.18). "One area resident has stated that at times the water in the drains kills his grass" (Wood, p.20).

Wood (p.18) also noted that "oil well odours" had been common in the Petrolia area. These odours have been markedly reduced during the past several years as some operators installed holding ponds and disposal wells. Hydrogen sulphides and mercaptans are now able to disperse more effectively before they enter the stream or water courses.

Based on these considerations a program of gradual reductions in oil field brine discharges to surface water courses is desirable.

3.0 BRINE DISPOSAL TECHNOLOGIES AND SYSTEMS

At least five disposal and treatment technologies have been discussed and evaluated in the decade or so since the problem became an issue in Petrolia. For example, salt can be removed by reverse osmosis, but this technology is untested in the present context and it is likely to be prohibitively expensive in any event. Aeration of the fluid before discharge could reduce the sulphur odour by oxidation but would not affect the salt content.

Brine could be pumped into unlined settling ponds excavated in clay subsoil. However, these ponds would likely be plagued with odours, potential leakage to groundwater and difficulties in controlling discharges during wet periods. The installation of selectively perforated casing in oil wells could, in theory, limit the amount of water entering a well, but experiments along these lines have not been successful. Finally, the fluids can be pumped down into a porous stratum of rock below the oil producing zone called the Detroit River Formation. Comments on the five proposed methods are summarized in Table 3.1.

On the basis of technical feasibility and a preliminary comparison of the gross costs of the five approaches, disposal of the brine into the porous Detroit River Formation emerged as the preferred method. An intensive hydrogeological study of the environmental implications of brine disposal to the Detroit River Formation concluded that long-term disposal of oil-well brine would be environmentally acceptable in the amounts currently being generated in Petrolia (Underground Resources Management, Inc., 1984).

To inject brine fluids into the Detroit River Formation, a well in the Petrolia area must be drilled to between 200 and 230 metres (600 - 700 feet). The well must then be cased through the shallower oil-producing zone to prevent leakage of brine back into the oil formation. In addition, design precautions must be taken to minimize exposure to air since the sulphurous formation fluids can become highly corrosive when oxidized to sulphuric acid.

An entirely new disposal well may be drilled or an existing oil well may be extended to the desired level, cleaned out, refurbished and converted into a disposal well.

Under current provincial Regulations (as administered by the Ministry of Natural Resources), all formation fluids generated from new oil wells must be disposed of in an environmentally acceptable manner such as deep well

TABLE 3.1

Brine Disposal Technologies and Options

1. Reduction of Brine production by setting packers in oil wells.

   Pipe and cement casing is installed down to the bottom of the well. Casing is selectively perforated at precise depths, limiting the amount of water which can enter the well. Based on experiments, the Committee concluded that this method would not achieve a sufficient reduction in brine production.

2. Evaporation from Unlined Settling Ponds

   Brine would evaporate during the summer. However, sufficient capacity would be required to allow controlled discharge during periods of high natural runoff. This option was rejected because of likely odours, leakage to groundwater and difficulties in controlling discharges.

3. Salt Removal by Reverse Osmosis

   Reverse osmosis would remove, at most, 50% of the salts from the brine. This technology was rejected because it was virtually untested for this application and would likely be prohibitively expensive.

4. Aeration of Brine

   Aeration of brine hastens the oxidation of sulphurous compounds, thus reducing odours. However, it would leave brine volumes and concentrations largely unaffected.

5. Disposal via New or Existing Wells

   Brine fluids would be injected by gravity feed into the porous Detroit River Formation which is deeper than the oil-bearing layers. Disposal wells were preferred on the basis of technical reliability and low cost.

Source: "Report of the Petrolia Oil Producers' Investigation Committee" (undated).

disposal. Moreover, the fluids cannot be injected under pressure, but rather by gravity flow.

At least four Petrolia producers have installed their own disposal wells. Bear Creek Resources (#3) was obliged to install a disposal well in 1983 in order to obtain permits to drill 12 new oil wells. Willis Jacques (#9) has refurbished an existing oil well and converted it into a disposal well in order to open new oil wells. Canflow Services (#6) has two disposal wells which were used in the 1960's to dispose of liquid industrial wastes from Sarnia until the practice was banned by the Province. At least one well is not in use at this time. A fourth producer, Cartier Resources (#7), has also recently installed a disposal well.

Brine disposal system options involving wells can be organized along two dimensions. The first dimension concerns the number of disposal well facilities in the system. A fully centralized service would have one central facility for the disposal of brine from all producers. A completely decentralized service would require disposal wells to be installed by each operator. The centralized option would minimize total facility installation costs, but would maximize transport costs. A decentralized approach would likely involve much lower transport costs, but each producer would have to incur installation costs.

The second dimension concerns transport methods or modes. At one extreme is a system in which all of the brine moves by a pipeline from each producer to a disposal facility, with the other extreme having all brine trucked.

The lowest cost solution will likely be some point between the two extremes of each dimension.

Based on these two key dimensions, five brine disposal systems were postulated for analysis with the location-allocation model. The first two options are polar cases.

(1) Construct disposal wells at each producer site.

(2) Require truck transport to a centralized disposal facility. This would be one of the fastest programs to implement.

(3) Find the least-cost location(s) of centralized disposal well facilities among all possible sites (called "nodes" in the model) in the Petrolia area.

(4) Find the least-cost location(s) of centralized disposal well facilities only among the existing oil producer sites.

(5) Locate centralized disposal well facilities only at the producers who have already installed disposal wells.

4. LOCATION-ALLOCATION MODEL SPECIFICATION

Location-allocation models are designed to determine optimum solutions to problems in which one or more central facilities must serve a spatially dispersed demand. A comprehensive review of this type of problem is presented in Handler and Mirchandani (1979). Such models vary in application from social services such as fire stations and schools to retail stores, warehouses and factories. In the present study, the facilities are central disposal wells, the service is brine disposal and the demand is generated by existing producers. The location-allocation model in this study has been structured so as to determine the optimum number, size and locations of disposal facilities, the pattern of allocation of demand to facilities and the optimum method of transport. Model elements will be expressed in economic terms and the optimum solution will be defined as the one with the least cost incurred to the system as a whole.

It is assumed that the space in which the model will be constructed is discrete. In other words, the set of all possible places or "nodes" in the study area is finite, of size n. In the present application, the total set of places (at node j) is the set of producer locations, denoted by a positive production, w_j, per unit of time, plus the set of places considered to be candidate nodes which are not producers. A node, i, is a candidate if $c_i=1$, otherwise $c_i=0$.

The allocation of brine from producers to disposal facilities is denoted by the matrix $\underline{x}$; $x_{ij}=1$ if brine from a producer at node j is transported to node i for disposal, else $x_{ij}=0$. Th cost of transporting one unit of brine by the cheapest available mode is given by d_{ij}, so the total transport cost for one unit of time is:

$$\sum_i \sum_j x_{ij} d_{ij} w_j \tag{1}$$

The elements of the matrix $\underline{x}$ must be constrained to ensure that all brine is disposed of:

$$\sum_i x_{ij} = 1 \quad \text{if } w_j = 0 \tag{2}$$

and that allocations are made only to candidate nodes with open facilities:

$$x_{ij} \leqslant x_{ii} \leqslant c_i \quad \text{for all } i,j \tag{3}$$

Finally, it is assumed that each producer transports all of his brine to one facility:

$$x_{ij} = 0,1 \quad \text{for all } i,j \qquad (4)$$

The number of facilities, p, will be equal to the trace of the $\underline{x}$ matrix while the objective will be to minimize the sum of the transport and facility construction and operating costs.

In this particular implementation of the generic model, brine production rates and transport costs are known, and the task is to determine the optimum allocation matrix $\underline{x}$, which will indicate the lowest cost pattern of transport and the number and locations of the disposal facilities. The literature refers to this as a plant location (Efroymson and Ray, 1966) or warehouse location (Feldman, Leherer and Ray, 1966) model. In this application, the number of brine disposal facilities, p, is determined by successively optimizing for a range of possible p values and selecting the least cost result. Thus, we impose the additional constraint in the solution process:

$$\sum_i x_{ii} = p^* \qquad (5)$$

where p* is a possible value of p.

The location-allocation model for analyzing oil field brine disposal begins with cost functions for the two transport modes. A permanent pipeline, from each producer's separator, to central facilities would require that the brine be moved by pumping. It would also be necessary to bury the pipe for winter operation, since the freezing point of the fluid is close to that of water, and it is possible that long term use would result in clogging by residual hydrocarbons. The useful life of suitable pumps is also unclear since this form of transport is essentially untried. The alternative transport mode is trucking. If this mode were adopted, it would be necessary to install insulated holding capacity at each production site to allow for winter operation.

The cost of a pipeline for each producer is computed by using the equation:

$$C_1 = A*D_o/B + C \qquad (6)$$

where:

C_1 = cost of piping to producer per year
$A*$ = cost of laying pipe \$/m
D_o = length of path between producer and disposal facility, m.
B = expected life of pipe, years
C = pumping cost to producer, \$/yr.

Trucking cost is determined with the equation:

$$C_2 = E*D*V_o/(365*F) + Q*V_o*(H + D_o/(1000*P))/G \qquad (7)$$

where:

C_2 = cost of trucking to producer per year
E = maximum brine holding period, days
D = holding capacity cost, \$/m^3
V_o = volume of brine to be disposed of by producer each year
F = expected life of holding capacity, yrs.
Q = truck operating cost, \$/hr.
H = time to load and unload truck, hrs.
P = truck average speed in motion, km/hr.

The term 'expected life' can mean either the financial amortization or depreciation period or a useful life of a facility, as appropriate. The cost per year is computed, in each case, as the relevant capital cost divided by the 'expected life' to the nearest year.

Piping thus has a fixed cost component (the cost of pumps), plus a component that is linearly dependent on distance, but is substantially independent of volume. Trucking has a nonlinear dependence on both volume and distance. The result is that trucking is least-cost for small volumes while, for large volumes, piping is more cost effective. However, the volume at which the least-cost mode changes depends on distance in a complex way. It is possible to compute the "break volume" (e.g. the volume at which the least-cost mode changes from trucking to pipeline) by equating the two expressions above and solving for V_o, to obtain the equation:

$$V_o = (C + A*D_o/B) / [E*D/(365*F) + Q*H/G + Q*D_o/(1000*P*G)] \qquad (8)$$

As distance tends to zero, break volume tends to:

$$V_o = C/[E*D/(365*F) + Q*H/G] \quad (9)$$

For the default values used in this study, the break volume at zero distances amounts to 658 m^3 per year. In other words, for very short distances, a producer would find it cheaper to truck brine volumes below 658 m^3 per yr. Above this volume, a pipeline system would be cheaper.

At large distances, the break volume is asymptotic to a limit given by the following expression:

$$V_o = A*P*G*1000/(B*Q) \quad (10)$$

Using the default values, the break volume for long distances is equal to 26,351 m^3/yr, below which it would be cheaper to truck brine to a central facility.

The location-allocation model consists of 5 IBM PC programs. The solution process embodied in these programs is outlined in Appendix A.

Disposal wells have an upper limit to the flow that can be accepted and dispersed continuously over an extended period of time. The Willis Jacques disposal well is reported to have easily absorbed the equivalent of an annual brine production of 40,000 m^3, while the Bear Creek well has been tested at the equivalent of 440,000 m^3 per year, but only for a short period.

Until better data are available, the long term capacity of a "standard well" will be assumed to be 300 m^3/day or 109,500 m^3/year of brine. The default value for brine production is 20:1 for each producer or about 125,000 m^3 per year from all producers. Thus at least two disposal wells will be needed to accommodate all brine. Furthermore, each centralized disposal facility would require two disposal wells. One would be a back up to ensure continuous operation and prevent the discharge of brine onto land or into area watercourses when one well is out of commission.

Based pn discussions with Petrolia producers, the average pipe installation cost is estimated to be \$30/metre although this figure is very uncertain. The actual costs would likely be much higher within the urbanized part of Petrolia where streets may have to be dug up and the costs may be lower for some producers whose operations are located near a disposal well. Moreover, the model computes the cost of a separate pipeline for each producer. Total installation costs could be reduced if piping were laid so as to carry brine from more than one operator.

Pumps would be necessary at each production site to push the brine into the system. Pumps may also have to be replaced frequently because of the corrosive nature of the fluid. Based on information supplied by Petrolia producers, it is estimated that pumps could have to be replaced as often as twice annually at a cost of $1,000 per change. Total pump costs could amount to $2,000 per year per operator. There are, however, corrosion resistant pumps available and the costs cited here are likely to be over-estimates.

Brine can be trucked between producer and disposal facilities using the same type of vehicles currently being used to haul oil. Harold Marcus Ltd., the company which ships all oil produced in the region to Sarnia, has four sizes of tank truck: 21 m^3, 15 m^3, 12.75 m^3 and 9.50 m^3. A 12.75 m^3 capacity truck can make a round trip of up to 8 km in two hours, including loading and unloading, at a cost of about $40/hour. To permit operation in the winter, it would be necessary to install insulated storage tanks at the production site large enough to hold a week's production of brine. Based on discussions with Petrolia producers, each m^3 of insulated capacity would cost $100.00 to install.

Producers have reported that the total cost of drilling and completing each disposal well was between $50,000 and $75,000 in current dollar values. The higher figure results from using all new equipment and salaried labour. Costs can be reduced by employing used equipment and pipe and by owner-operators doing the work themselves.

Unfortunately, a well drilled for disposal purposes may not be successful because the permeability of the Detroit River Formation is highly variable over short distances. A local petroleum engineer estimated that a disposal well in the Petrolia area will have an 80% probability that it will be capable of accepting the desired flow of brine under the conditions imposed by the Ministries of Natural Resources and the Environment; perhaps even as low as 60%. This is another reason why an extra backup well will have to be installed at each centralized facility if it is to be operated continuously.

Given this uncertainty and the fact that disposal well installation costs can be kept low through careful design features or by the conversion, in some instances, of a disposal well to oil production, $60,000 will be used as the default value for this capital cost of installing a successful disposal well. This cost does not include any associated separation, retention or aeration facilities.

Although a successful disposal well can be depreciated for tax purposes over five years, it is not yet clear just how long a brine disposal well will last physically. Corrosion and the clogging of the Detroit River formation can limit the usable life of a well. Clogging can be avoided by filtration and settling prior to injection. Otherwise lengthy, expensive and uncertain treatment procedures are required to unclog the receiving formation. Because the operating life of a disposal well may be no more than three or four years, it would be unwise to require the installation of a large number of such wells before more operating experience has been accumulated.

In the model a producer is represented as a point, or "node", and is located at the precise map co-ordinates of the brine separator and oil storage facilities currently in use. These nodes were plotted on 1:10,000 sheets produced by the Ministry of Natural Resources' Ontario Base Mapping program (sheet numbers 10 17 4000 47450, 10 17 4050 47450, 10 17 4000 47500 and 10 17 4050 47500).

Fourteen out of the 17 active oil producers on the Petrolia field which could be located with certainty are specified in the model. These 14 producer locations are designated as the first 14 nodes in the model. Possible transport connections between them are limited to existing public or private roads. Heavily urbanized sections of Petrolia are excluded when possible. The junctions of this network are also designated as nodes, numbered from 15 to 34 inclusive. Road connections between the nodes are designated as "links". Because the network is fully connected, it is possible to find a path along the links to connect any pair of nodes. The nodes and pathways are shown in Figure 2.2.

The model can be used to determine the node(s) where brine from each of the producers can be disposed of at the lowest transportation cost. The model can also be used to determine which transport mode, pipeline or truck, should be used to move the brine, given the relative costs of each method and the volume of brine that must be transported.

Model parameters are summarized in Table 4.1 along with the values for each parameter. The uncertainties and biases which are associated with the various parameter values are summarized below:

(1) The installation cost of a pipeline for centralized facilities is uncertain because there is no experience in constructing such a system. It is not known whether the $30 per metre estimate used in the model is an under- or over-estimate.

TABLE 4.1

Summary of Default Values for Petrolia Oil Field
Used in the Location-Allocation Model

Symbol	Parameter Description (units)	Default Value*
	Piping option parameters:	
A	Cost of laying pipe ($/m)	30
B	Expected life of pipe (yrs.)	10
C	Pump cost ($/yr per producer)	2000
	Trucking option parameters:	
D	Holding capacity cost ($/m^3)	100
E	Maximum holding period (days)	7
F	Expected life of holding capacity (yrs.)	10
G	Truck load (m^3)	13
H	Time to load and unload (hrs.)	1
P	Truck speed (kph)	25
Q	Truck cost ($/hr)	37
	Disposal well parameters:	
R	Cost of completed well ($)	60,000
S	Expected Life of well (yrs.)	4
T	Capacity of well (m^3/day)	300
U	Brine/oil ratio, assumed constant for all producers	20

* Sources of default values are discussed in text.

(2) The cost of a separate pipeline between each oil producer and a disposal well site was estimated by the model. Some oil producers could conceivably share pipelines so that total pipeline installation costs are likely over-estimated. Since the model cannot be modified to account for shared pipeline, the cost of laying pipe could be reduced.

(3) Corrosion could require more frequent pipeline replacement or maintenance. This consideration would increase the per-metre costs of the pipeline.

(4) It is assumed that pumps will wear out quickly and that operators would have to buy two new pumps per year at $2,000 per year per operator. This assumption is likely to yield an over- estimate of annual pumping costs.

(5) If average brine to oil ratios are actually higher than 20:1, total disposal costs would be somewhat higher because of higher trucking costs and, perhaps, the need for more disposal wells.

(6) A disposal well is assumed to last only 4 years. A simple average annual cost was calculated by dividing the total estimated capital cost (e.g. $60,000) by four. Interest on this money is ignored for this period of time. If disposal wells last longer than 4 years, the annualized facility or capital cost would be proportionately lower although interest charges would begin to be felt.

(7) Operating costs of disposal wells are negligible if the brine is transported by gravity through on-site piping (J. Gauvreau, 1985). If the operating costs of a pipeline system are found to be higher, they can be expressed by decreasing the expected life of the disposal wells (currently set at 4 years) or the pipeline system (currently at 10 years) for future model runs.

5.0 MODEL RESULTS AND SENSITIVITY ANALYSES

Analyses of the five disposal system options specified in Section 3 using the default values are summarized in Table 5.1.

The first option, construction of a disposal well at each producer site would impose $60,000 on each producer or $660,000 in additional capital costs for all 14 Petrolia producers. This would amount to about $165,000 per year or $1.32 per m^3 of brine disposed. A $60,000 capital outlay or even a $15,000 annual payment would constitute a financial burden on some producers whose annual revenues are in the $40,000 to $75,000 range.

The remainder of the options involved application of the location-allocation model to find the optimal (lowest cost) central disposal well sites under different conditions and system options.

Option 2 is the polar case where all operators have brine hauled to centralized disposal sites by truck. The advantage of this system is that it could be implemented almost immediately so long as truck capacity was available. Although two wells at one site would be sufficient to dispose of all Petrolia brine, the model revealed that centralized disposal wells at two sites, the Edward and the Jacques properties, would minimize transport costs. Jacques has already installed a disposal well so that only three new wells would have to be constructed. The total cost of this option could amount to as much as $440,827 per year or nearly $3.53 for every m^3 of brine disposed. Total transport costs would come to $396,000 per year or $3.17 per m^3 of brine.

Under options 3 and 4, the model was employed to find the least cost centralized disposal sites among the 34 potential "nodes" in the Petrolia system and among the 14 operated sites. Only two sites would be needed in each case. Because of the distribution of operators in and around Petrolia and the geometry of the network, in which large cost penalties are incurred in moving bring around the built-up parts of Petrolia, the optimal locations are in the northwest and southeast quandrants. The facility in the northwest must accept 103,064 m^3 of brine each year from 11 of the producers while the remainder, 28,828 m^3 are directed to the southeast facility from the three producers in that area. In both cases, only 2,600 m^3 of brine would be trucked; the rest piped.

These results show that there is no substantial difference between the transportation and total costs of a

TABLE 5.1

Comparison of Brine Disposal Facility Location and Transport Options

Option	Location of Brine Disposal Facilities	Quant. Brine Disposed at each Well (m^3/yr)	Total Capital Cost for Wells $	Costs per year Facil. Costs $	Transp. Costs $	Total Cost $	$/$m^3$ Brine Disposed	$/$m^3$ Oil Produced in 1984*
1. Disposal well at each	3 Existing wells	-	-	-	-	-		
producer site	11 New wells	125,000	660,000	165,000	-	165,000	$1.32	26.42
2. Central disposal	8 Edward	103,065	120,000	30,000	325,145	355,145		
system using only	9 Jacques	21,828	60,000	15,000	70,682	85,682		
truck transport		124,893	180,000	45,000	395,827	440,827	$3.53	$70.59
3. Least-Cost, locate	4 Bender	21,827	120,000	30,000	17,190	47,190		
disposal wells at	23	103,064	120,000	30,000	62,429	92,429		
any of 34 Nodes		124,891	240,000	60,000	79,619	139,619	$1.12	$22.36
4. Least-Cost, locate	4 Bender	21,828	120,000	30,000	17,190	47,190		
disposal wells at	8 Edward	103,065	120,000	30,000	63,468	93,468		
existing producer sites		124,893	240,000	60,000	80,658	140,658	$1.13	$22.52
5. Locate facilities	3 Bear Creek	103,065	60,000	15,000	64,890	79,890		
at existing	9 Jacques	21,827	60,000	15,000	27,141	42,141		
disposal wells		124,892	120,000	30,000	92,031	122,031	$0.98	$19.54

* Based on a total (1984) oil producion of 6,245 m^3 from 14 operators in the Petrolia Pool.

system that could locate wells anywhere among the 34 nodes or one that is anywhere among the 34 nodes or one that is restricted to the 14 existing producers. However, these optimal locations would require that a total of four new disposal wells would have to be constructed at a capital cost of $240,000. These capita costs would increase the annual cost by $60,000.

Option 5 specifies that the location of central facilities must be chosen from among producers with existing disposal wells. Of the four producers which currently have disposal wells (Bear Creek (#3), Cartier (#7), Jacques (#9) and Canflow (#6)) the Canflow site would be ineligible for centralized disposal. The Canflow wells were used for the disposal of chemical wastes before this practice was banned in the middle 1970's. Substantial increases in fluid injection resulting from the use of this well as a centralized facility would run the risk of pushing the chemical waste materials into other wells and ultimately contaminating ground or surface waters.

When the number of eligible central disposal sites are reduced to three producers who already have disposal wells and who would only have to install one more for back up, the transportation costs would increase only slightly to $92,031 per year (from around $80,000 per year).

However, at a total annual cost of $122,031 per year or 98¢ per cubic metre of brine, this system is the least cost. This occurs because the capital component amounted to $30,000 per year rather than $60,000. The transport cost ($92,031) of this component is not uniformly distributed over the producers. The highest cost per m^3 is between 3 and 5 times the average. Higher transport costs tend to accrue to the smaller, more peripheral producers.

The location-allocation model indicated that a centralized disposal system which included all three of the eligible sites (i.e. Bear Creek, Cartier and Jacques) would minimize transport costs. That is, transport costs would be no more than those incurred under options 1 and 2; $70,000 - $80,000 per year. However, three extra disposal wells would be required at a cost of $45,000 per year or a total annual outlay of $124,084. Consequently, the overall least-cost centralized system would locate disposal facilities at the Bear Creek (#3) and Jacques (#9) sites.

Based on the assumptions and default parameter values used in this analysis, the potentially lowest cost system to dispose of all formation fluids into disposal wells would utilize existing disposal wells and could impose as much as

$122,000 in extra costs per year on the 14 operators in and around Petrolia. However, these results assume installation of a pipeline transport system which could take a year or more to install. Trucking the brine to disposal wells could begin immediately but this transport mode would cost Petrolia operators as much as $441,000 per year.

Uncertainties and biases are associated with some of the model parameters. A sensitivity analysis shows how changes in different parameter values would affect the characteristics of the optimal (least-cost) brine disposal systems. Most of the sensitivity tests carried out in this study involved changing the values of a single parameter or variable while leaving all others at default levels. One test was made in which several parameter values were adjusted so as to postulate extremely high-cost conditions.

The model was used to compute the following results for comparison:

- Breakpoints limits.
- Distribution of transport costs between trucking and piping.
- Least cost sites for centralized disposal wells from among 14 producers.
- Allocation of brine between pipeline and trucking transport modes.
- Total transportation costs per year.

The values to be applied in the sensitivity analyses are summarized in Table 5.2 together with the results of these analyses.

Because the parameters related to piping are so uncertain, each of the three variables which determine the annual cost of a pipeline system was varied in the following ways. The cost of laying pipe (A) was increased by 100% and decreased by 50% to $60 and $15 per metre respectively. The lower cost represents a system whereby producers share pipelines to a central facility and will need to install much less piping than is assumed by the model. The expected life of the pipeline (B) was decreased from 10 years to 8, 6 and 4 years. A lower life (or more frequent replacement) of pipelines could result if the pipes clog up with waxes or freeze during the winter. The default value for the annual cost of a pump (C), $2,000 per producer per year, is based on the assumption that 2 pumps would have to be purchased each

TABLE 5.2

Summary of Results of Sensitivity Analyses

Parameter (Lable) = New Value*	Ship by Pipe if above: Short Distances (m^3/yr)	Long Distances (m^3/yr)	Percent Transportation Costs Pipe	Truck	Least Cost Producer Sites	Brine Volumes (000m^3) Pipe	Truck	Transportation Costs ($000's)
1. Default Parameters**	658	26,351	74	26	4, 8	122.3	2.6	80.7
2. Pipe Cost (A) = 60	658	52,703	53	47	2, 4, 7, 9	120.1	4.8	76.3
3. Pipe Cost (A) = 15	658	13,176	87	13	4, 8	122.3	2.6	56.6
4. Exp Pipe Life (B) = 8	658	32,935	67	33	2, 4, 7	122.4	2.5	72.96
5. Exp Pipe Life (B) = 6	658	43,919	62	38	2, 4, 7, 9	122.4	2.5	69.4
6 Exp Pipe Life (B) = 4	658	65,878	47	53	2, 4, 7, 9	120.5	4.4	86.0
7. Pump Cost C = 1000	329	26,351	77	23	2, 4, 7	122.4	2.5	52.8
8. Pump Cost C = 500	165	26,351	77	23	2, 4, 7	122.4	2.5	46.8
9. Cost of Completed Well R = $100,000	658	26,351	74	26	4, 8	122.3	2.6	80.7
10. Cost of Completed Well R = $40,000	658	26,351	74	26	2, 4, 7, 9	121.8	3.1	54.6
11. Expected Life of Well S = 8	658	26,351	74	26	2, 4, 7, 9	122.3	2.6	54.6
12. Brine/Oil Ratio U = 30:1	658	26,351	82	18	2, 4, 7	183.4	3.9	69.0
13. Brine/Oil Ratio U = 40:1	658	26,351	90	10	2, 4, 7, 9	249.8	0	59.8
14. Brine/Oil Ratio U = 60:1	658	26,351	96	4	2, 4, 7	374.7	0	70.1
15. A = 60, R = $100,000, U = 40:1	658	52,703	77	23	2, 4, 7, 9	244.6	5.2	85.2

* Model runs are carried out by changing only the parameter indicated and leaving all other default values changed except #15.
** See Table 4.2.

year, a somewhat pessimistic expectation. Real annual pump costs would likely be lower so that alternative parameter values of $1,000 and $500 were used in the sensitivity tests.

If piping costs were to increase relative to trucking, some producers would find it cheaper to send brine by truck so that a larger proportion of the brine produced would be shipped by that mode. If the transport modes were to change, it is likely that the optimal central disposal site locations would be changed as well. However, if piping costs decrease relative to trucking, producers would have an incentive to send a greater proportion of brine by pipeline and it is unlikely that optimal centralized disposal well locations would differ from those for the default values.

Trucking mode parameters (D through Q in Table 4.2) are more certain since they were reported as actual costs by the trucking company that serves the Petrolia area producers. Consequently no sensitivity tests were performed with these parameters.

Disposal well cost parameters are also uncertain. As noted, the cost of completing a disposal well could be cheaper than the $60,000 default value if a producer did the work himself and employed used equipment. A well could also be more expensive if a producer had to hire someone to install a well. Consequently, alternative installation costs of $100,000 and $40,000 per well were used in the analysis. Because disposal site locations are determined by transport costs, it does not appear likely that installation costs would affect the optimal location of the centralized disposal sites. These cost changes will most certainly affect the total cost of the brine disposal system.

The expected life of a disposal well was postulated to be no more than 4 years in the default values. However, the wells will probably last much longer. An 8-year value for the expected life of the disposal well (S) was, therefore, examined. A longer life span would lower the overall cost of disposal but would not necessarily affect the optimum siting of centralized disposal facilities.

The capacity of a single brine disposal well is very uncertain but the figure used in the default values is considered to be somewhat lower than is likely. Consequently, no alternative value was tested in this exercise.

Finally, it is possible that the average brine-to-oil ratio would be higher than 20:1 while the likelihood that the

average ratio would be lower is remote. Therefore, three different ratios were tested: 30:1, 40:1 and 60:1. If more brine is produced, more disposal well capacity would be needed so long as disposal rates at a given well do not change beyond the default value. Moreover, pipeline transport would be favoured since trucking costs are directly proportional to brine volume. Increases in the generation of brine from each well would not likely affect the optimal disposal well locations or the transport costs if piping were used.

A summary of the results of the sensitivity analyses is presented in Table 5.2. The most striking, and surprising, result is that nearly all changes in the parameter values would change the number and location of the optimal disposal sites. Using the default values, the Bender (#4) and the Edward (#8) sites would achieve the lowest transport costs. However, all but two of the sensitivity tests prompted a shift to the Ayrheart (#2), Cartier (#7) and Bender (#4) sites as the least-cost locations. In a number of cases, the addition of the Jacques (#9) site is indicated. The location of these sites are shown in Figure 2.2.

Under very high cost conditions where the parameter set included a pipe cost of \$60/metre, a cost of a completed well of \$100,000 and a brine to oil ratio of 40:1, the four sites, 2, 4, 7 and 9, were specified as the optimal sites.

Based on the analyses that were carried out, total transportation costs would increase above the amount indicated for the default values (i.e. \$80,658 per year) in only three cases: where pipe cost was increased to \$60/metre, where the expected pipe life was dropped to 4 years and where the cost of a completed well was raised to \$100,000. Some remarkable cost decreases occurred under a variety of changes. For example, decreases in the annual pump cost lowered the total transport cost by 37 to 42 percent. Total transport cost is also sensitive to the cost of laying pipe (A).

Based on these analyses, the factors that have the most influence on the costs of a centralized brine disposal program are the cost of laying pipe (or the total amount of pipe required), the annual cost of brine pumps (i.e. how long will they last?) and the cost of a completed disposal well. It would appear that the brine to oil ratio has a relatively small effect on transport costs although higher volumes of brine would virtually eliminate the demand for truck transport.

6.0 ECONOMIC IMPLICATIONS OF ALTERNATIVE BRINE DISPOSAL SYSTEMS

Operators may install their own disposal wells or they may transport the brine to central facilities for disposal. These two basic approaches have different financial implications.

Under a dispersed disposal system, each producer builds his own disposal wells. Each will each face an installation, or capital, cost of up to $60,000. As long as brine can be transported from oil wells to the disposal well by gravity, operating costs are negligible.

The installation cost can be financed from the operator's own funds or by debt. If each of the 11 operators who have not already installed disposal wells were to finance a $60,000 capital cost out of current revenues, this expense would consume between 26% and 33% of the total annual revenue for three of the operators and between 87% and 560% of the annual revenue for the remaining eight.

Direct financial impacts would be mitigated somewhat if operators borrowed the funds. The annualized capital cost used in the analyses amounted to $15,000 per year. This expenditure would consume between 6.5% and 22% of the total 1984 annual revenue of seven operators. An expenditure of $15,000 per year would still amount to over 100% of annual revenue for two operators and between 25.7% and 68.3% for the remaining five operators.

Using 1985 total revenues, a $15,000 average annual expenditure would consume less than 25% of the total revenue for 8 out of 17 operators while it would amount to over 100% for two producers. Of the remaining 7, $15,000 would account for between 27% and 82% of total revenues.

Furthermore, as shown in Table 5.1, if each producer had to install a disposal well, the average cost of 1984 oil production from the Petrolia pool would increase by $26.42 per cubic meter of oil. As of December, 1986 the price paid for Petrolia field crude oil was $125.00 per m^3.

By contrast, drilling and completing a new Devonian oil well costs about $40,000. Costs per well could be somewhat lower if a number of wells were installed at one time (Bailey Geological Services Ltd, 1985: 100-122).

A program that requires all producers to install their own disposal wells, or to truck all brine to existing central disposal facilities, would be unnecessarily costly. The results presented in Table 5.1 indicate that a centralized system using both truck and pipe modes is cheaper in the aggregate and would impose lower costs on many individual producers than would be the case if each operator installed his own well.

The analyses also suggest that it would be most cost-effective to establish two central disposal facilities at producers' sites who have already installed a disposal well. This result is due to the fact that only one new well, rather than two, would have to be constructed where disposal wells already exist.

A two-site, centralized disposal system, Option 5 in Table 5.1, would impose on Petrolia producers an extra \$19.54 in cost per cubic metre of oil produced.

In addition to transportation costs, each producer who uses a central disposal service would have to pay something to the operator of the disposal facility. The appropriate price for a service like this is the marginal or extra cost of supplying it. Since producers will pay their own transportation costs, the relevant price to be paid to operators who provide disposal services would be the extra cost of installing and operating the disposal wells, plus a "normal profit". For this exercise, a "normal profit" is defined as a 12% annual return on new capital invested.

Consequently, if central disposal facilities were established at the Bear Creek Resources and Cartier sites, the extra costs that would be used to define disposal prices would be \$15,000 per year for one extra brine well plus \$7,200[2] for "normal profits", for a total of \$22,700. The capital costs of the existing disposal wells are "sunk" costs which the operators would have incurred in any event and so are not included in this calculation.

Under Option 5 in Table 5.1, the Bear Creek facility would dispose of 103,065 m^3 of brine. Thus, the minimum annual price to be charged by Bear Creek to recover incremental or "marginal" costs would be \$0.22 per m^3 while Jacques' minimum charge would have to be \$1.04 per m^3. Using these disposal charges, the cost to all of the Petrolia producers would be about \$29,500 over and above the \$92,031 in transport costs. The two producers who operate the central disposal wells would not incur extra disposal charges. About 62% (\$18,200) of the annual disposal charge

---

[2] \$7,200 is 12% of a \$60,000 capital investment.

revenue would go to Bear Creek while the remainder, \$11,323, would be received by Jacques. These revenues would offset the annual capital charge for the disposal wells which amount to \$15,000 per year.

Charging a different disposal price at each facility may raise questions of equity. However, different prices are often charged for similar services to different customers by water, telephone or power utilities. Moreover, if oil producers opted for a different arrangement or tried to re-direct brine from, say, the Jacques to the Bear Creek facility, the extra transport costs would be much higher. In any event, the different prices reflect the different costs involved in supplying the service, not a higher profit to one of the disposal well operators.

In order to assess the impact of the costs of this disposal system on individual Petrolia producers, estimates of oil production operating costs and the resulting net revenues are required. Cost data from two large and one small oil producer are presented in Table 6.1. Assuming an average oil production of 40.29 m^3 per well per year, the apparent average cost attributable to these operators range from \$89 per m^3 to \$240 per m^3. These average costs may be overstated in that depreciation represents funds that are actually retained by the operator. However, the average cost per m^3 of oil reported by one of the large producers is higher than the most recent oil price, \$125 per m^3.

As shown in Table 6.1, the lowest cost brine disposal option could add, on the average, an extra \$19 or \$20 to the cost of each m^3 of oil produced by Petrolia operators. While this may not force all producers into a loss situation, especially owner-operators who have relatively low-cost operations, the cost impacts could be problematic for some producers. However, these estimates probably overstate disposal costs to Petrolia producers as many will find it cheaper to install their own wells than to pay disposal fees.

The sensitivity analyses revealed that deviations from the default values would result in a change in the optimal locations for disposal wells. The sites that were noted include two sites which already have disposal wells installed on them. The Cartier and the Jacques sites together with Bear Creek and Bender operations appear to be the most suitable under a variety of potential conditions to which the system might be subjected.

TABLE 6.1

Annual Oil Production Costs of Devonian Producers in Petrolia, Ontario

Cost Items	"Large" Producer #1 (24 wells)	"Large" Producer #2 (18 wells)	"Small" Producer (4 wells)
Direct Expenses			
Hydro	N/A	3,288	625
Labour	N/A	34,000	7,800
Depreciation	56,927	12,000	2,460*
Hardware/maintenance	N/A	24,000	1,692**
Transportation	7,865	4,095	750
Taxes	N/A	N/A	1,069
Sub-total	174,079	77,383	14,396
Administration/ supervision/financial carrying costs, etc.	58,304	12,000	***
Total Costs	$232,383	$89,383	$14,396
Cost/well	$ 9,683	$ 4,965	$ 3,599
Cost/average m^3 oil	$ 240	$ 123	$ 89

* Estimated on the basis of $11,500 @ 12% over 10 years and 1,018 @ 12% over 3 years.

** A simple average of $848 in 1984 and $2,535 in 1983.

***Operator does not charge for own time. If he did, this item would amount to an additional $6,000 to $12,000/yr.

Based on the foregoing analyses, operators with existing disposal wells should be a point of departure for a centralized brine disposal system. The use of existing disposal wells holds the promise of minimizing both transportation and total disposal costs for all producers. Moreover, it would permit the development of a systematic program in which the remaining uncertainties and problems associated with the program could be identified and, hopefully, resolved.

7.0 CONCLUDING REMARKS

Location-allocation modelling techniques have been applied to the problem of oil well formation fluid disposal in Southwestern Ontario. Although the central vertex substitution algorithm is well known, certain features of this particular application are novel, including the complexity of two transport modes, one of which is nonlinear in distance. Another unique feature is the use of add and drop heuristics in addition to vertex substitution. Both of these features are likely to reduce the efficiency of the optimization procedure and increase the probability of detecting local optima. However, this problem is relatively small and the user can easily test the effects of varying the starting solution.

The operational model was structured as an interactive package for the PC so as to allow for continuing dialogue between the parties concerned as implementation proceeded. For example, it is likely, given the recent declines in oil prices, that both production levels and the set of active producers will change before any plan can be implemented fully. It was shown by the sensitivity analyses that it is easy to examine the effects of such changes on the optimality of the solution using the model. Model results could be displayed in a graphic mode. However, the relevant software has not been implemented.

Parameter values should be verified for application of the model to other oil fields or to test the consequences of a specific disposal program. This can be accomplished by monitoring the operation of existing disposal wells with a view to improving designs, increasing the operating life and obtaining more accurate estimates of the relevant system parameters (e.g. installation costs, operating life of pumps, clogging of pipelines, etc.).

A demonstration project to test the installation and operation of a centralized disposal facility would be desireable. This project could involve existing disposal wells at Bear Creek Resources, Jacques or Cartier, together with nearby producers, particularly those which discharge brine into Buttermilk Creek. This project would be intended to investigate appropriate and acceptable institutional arrangements as well as the relevant technical features.

Brine from new oil production wells must be disposed of in approved disposal facilities, either centrally located or on-site. Over the longer term, a system of shared and private facilities should be evolved at minimum cost. Changes in the system should be monitored and incorporated into the location-allocation model so that periodic cost estimates of various options can be generated and relayed to new and existing producers who propose to implement acceptable brine disposal. As the necessary technology and administrative arrangements are proven, brine disposal requirements can be gradually extended to smaller producers whose brine causes less obvious problems.

BIBLIOGRAPHY

Bailey Geological Services Ltd. and Cochrane, Robert O. (1985). Evaluation of the Conventional and Potential Oil and Gas Reserves in the Devonian of Ontario (Vol. I). Open File Report 5555, Toronto: Ministry of Northern Affairs and Mines, Ontario Geological Survey.

Efroymson, M.A. and Ray, T.L., 1966. 'A branch-bound algorithm for plan location', Operations Research 14, pp.361-68.

Feldman, E., Leherer, F.A.and Ray, T.L., 1966. 'Warehouse location under continuous economies of scale', Management Science (A) 12, pp.670-84.

Gauvreau, J., Bear Creek Resources Ltd., (1985) Personal Communication.

Goodchild, Michael F. and Noronha, Valerian T. (Sept. 1983). Location-Allocation for Small Computers. Monograph 8, Iowa City, Iowa: Dept. of Geography, University of Iowa.

Habib, H.E. and Trevail, R.A. (1984). Oil and Gas Exploration, Drilling and Production Summary, 1982. Oil and Gas Paper 5, Toronto: Ontario Ministry of Natural Resources.

Handler, G.Y. and Mirchandani, P.B., 1979. Location on Networks: Theory and Applications. MIT Press, Cambridge, Mass.

Ontario, Ministry of the Environment, 1987. Options for The Disposal of Formation Fluids by Oil Producers in Petrolia, Ontario - An Environmental-Economic Assessment. Toronto: Ministry of the Environment.

Petrolia Oil Producers' Investigation Committee. (undated) Unpublished reports on brine disposal technologies.

Teitz, M.B. and Bart, P., 1968. 'Heuristic methods for estimating the generalized vertex median of a weighted graph', Operations Research 16, pp.955-61.

Trevail, Robert. 1987. Ontario Ministry of Natural Resources, Personal Communication.

Underground Resource Management, Inc. in Association with Gartner Lee Associates Ltd. (1984). Environmental Implications of Deep-Well Disposal of Brines to the Detroit River Group of Formations in Southwestern Ontario. Summary Report. London, Ont.: Ontario Ministry of Natural Resources.

Wood, T.E. (undated). "An Assessment of the Impact of Devonian Oil Production on the Environment in the Petrolia Area". (unpublished manuscript). Ontario Ministry of the Environment.

APPENDIX A

LOCATION-ALLOCATION MODEL

for

EVALUATING THE COSTS
OF BRINE WELL DISPOSAL OPTIONS

The Location-Allocation Model used in this study is adapted from a more general formulation developed by Professor Michael Goodchild (Goodchild and Noronha, 1983).

A location-allocation model is used to determine the best or optimal location for one or more facilities from which some service is to be provided to a dispersed population. The location problem concerns where to locate a facility, given knowledge of who is to be served by each facility. The allocation problem is to decide who should be served and from which facility. In most applications, including the present one, both problems must be solved simultaneously.

The model consists of five modules, as follows:

- SPA2. This program takes node and link data and finds the lengths of the shortest routes between all pairs of nodes. The input consists of two files, one of nodes and one of links, and the output is a file of weighted distances. The program uses a standard shortest path algorithm, and is described in detail in Goodchild and Noronha (1983). The version used is written in BASIC for the Microsoft MS DOS BASIC compiler. Both source and executable module are included;

- EDIT. This program is written in interpreted BASICA. It gives the user the facility to edit the existing parameters of the model or even create new ones. Model parameters include the costs of disposal wells and transport of brine. Fourteen parameters have been defined in the current model. The output is a file of parameters which are used in subsequent computations;

- ANAL. This program is written in interpreted BASICA. It takes a file of model parameters and allows the examination of various features of the transport cost functions of the two modes, trucking and piping. It also converts an input distance file into an output file of costs and associated transport modes;

- ALLOC. This program is a substanially modified version of the ALLOC described in Goodchild and Noronha (1983). It is written in compiler BASIC. Its purpose is to identify an optimum arrangement of facilities in order to minimize the sum of transport and facility costs. Details of the algorithm used are given in the discussion below; and

- EVAL. This program, in interpreted BASICA, is designed so various statistics on a given arrangement of facilities, either the optimum or some other alternative arrangement, can be obtained. It has been extensively modified from a version in the Iowa monograph.

Two versions of the nodes file have been created for modelling purposes. In the file NODES.PET, all nodes in the system are considered to be candidates, or potential locations, for disposal facilities. File PRODS.PET allows disposal facilities to be located only at producer nodes. Both files have the following format:

Six numbers, integer or decimal, separated by commas:

- node identification number, 1 through 34
- region number, always 1
- volume of oil produced in m^3 in 1984;
- 1, if node is a potential facility location, else 0;
- UTM easting of node, measured from 1:10,000 sheet; and
- UTM northing.

Links data have been coded in the file LINKS.PET, using the following format:

Three numbers, integer or decimal, separated by commas:

- origin node number (either end of a link can be regarded as the origin)
- destination node number; and
- length of link in metres

The EDIT module is designed so the model's 14 input parameters, which were discussed in the body of the report, can be changed. The full list of parameters with the associated default values is summarized in Table 4.2.

The strategy adopted by the ALLOC optimization program is to examine various arrangements of facilities among potential sites in a systematic search for the least-cost combination. Cost is expressed in all cases as dollars per year. It begins with an initial solution supplied by the user, which may be an intuitive guess, or may have arisen in a discussion and is a realistic possibility. The user may then select one of three algorithms to search for improved arrangements:

- Swap algorithm. This procedure systematically considers moving each of the facilities from its current location to each node which does not currently have a facility. Only one facility is

moved at a time. After examining all the possible moves that can be made, the algorithm adopts that move, if any, which produces the biggest saving in transport cost. The cycle is then repeated. The method is conventionally known as a vertex substitution or a Teitz and Bart algorithm;

- Add algorithm. Since the desired number of facilities is not known at the outset in this model, and since the swap algorithm maintains a constant number of facilities, two additional algorithms have been added to increase or decrease the number. The add algorithm examines each of the nodes which does not currently have a facility and determines the one which, if given a facility, would decrease the total cost by the largest amount. For the cost to decrease, it is necessary for the saving in transport cost resulting from the additional facility to outweigh the extra facility cost;

- Drop algorithm. This procedure examines possible removals of facilities from nodes which currently have facilities.

The mode of transport is not of immediate concern in the ALLOC optimization procedure, since it is assumed that the least-cost mode will be adopted in all cases.

The EVAL module identifies the transport mode of each producer, computes total and average transportation costs for each and generates a number of other useful statistics. The solution evaluated can be an optimized solution from ALLOC or any other test scenario.

When installed, the system is initiated by typing PET in response to the MS-DOS prompt. The remainder of the system is menu-driven. It is possible to define an AUTOEXEC.BAT file containing the word PET to avoid this step.

ooOoo

BEACHES IN LOTUS: A MICROCOMPUTER MODEL OF SPATIAL RECREATION BEHAVIOUR

Jack B. Ellis
Professor in Environmental Studies
York University

ABSTRACT

The search for a tool to understand shifts in the use of beaches in Ontario resulted in a two-stage gravity-based model being implemented on a micro-computer using the popular spreadsheet software, Lotus 123. The model draws on a database containing information on over 600 of the major beach locations in Ontario. It is structured to represent 11 origin zones and 13 destination zones at its inter-regional stage. At the intra-regional stage, it allocates beach use to each of over 500 separate locations.

The model is based on demographic-sensitive participation rates in swimming, and uses separate matrices for home-based and non-home based participation. It is sensitive to environmental and esthetic factors, and reflects instantly the effects of beach closures by reason of water pollution. It has been designed for future incorporation of economic valuation parameters, as well as for ease of use and quick updating by non-specialized personnel.

1. Beach Use in Ontario: An Overview

Beaches play a central role in recreation in Ontario. The very image of Ontario as a place to live and to visit is conditioned by the presence and availability of the many thousands of lakes, large and small, and by the many hundreds of kilometres of beaches along their shores.

This paper and the model results it discusses focus on the activity of swimming as the pre-eminent indicator of beach use. It must be noted that in addition to swimming, there is a considerable array of associated and related activities which also contribute to beach use, and to which the presence of beaches contributes, including both water-oriented and non water-oriented activities. The model discussed in this paper deals only with the swimming use, however, which can be seen as the main or key use in many locations.

To place the use of beaches and the activity of swimming in some perspective, Table 1, following, shows the estimated 1986

volumes of participation in the top eight outdoor recreation activities in Ontario:

Table 1: Participation in the Top Eight Recreation Activities

Activity	Participation Rate	Occasions/ Person/Year	Occasion Total (Millions)
Walking	56%	40	360
Swimming	66	20	180
Driving	63	18	162
Cycling	30	15	135
Cottage	47	9.5	86
Boating	38	7.2	65
Fishing	37	4.9	44
Picnicing	60	4.0	36

Sources: Basic data provided by Ontario government surveys and updated to 1986 by the author: Ontario Recreation Survey, (OSRD, 1976); Physical Activity Patterns in Ontario, (OMTR 1981, 1983).

While swimming is included as an outdoor recreation activity in the above list, it must be noted that about 60% of swimming activity actually occurs in pools. Natural environment swimming accounts for about 8 occasions per year per Ontario resident, including swimming done while out of the province. Some natural environment swimming is not done from beaches, but from docks, piers, or rocks. Somewhere between 5.0 and 5.5 occasions per capita per year occur of beach swimming within Ontario by Ontario residents, for a total of about 45-50 million occasions.

To this large number must be added between 2-4 million beach swimming occasions in Ontario which arise from non-resident visitors. Thus, the total number of beach-swimming occasions per year in Ontario can be seen to be about 50 million or slightly more.

2. Rationale for Modelling Beach Use

The questions leading to the development of the model described in this paper focussed on significant issues which arise from beach swimming occurring at this sort of volume:

- what happens to beach use patterns when the use of some of our popular beaches, such as those in urban areas, is curtailed as a result of water pollution?

- what economic valuation can be placed on the foregone use resulting from pollution, and thus what costs are reasonable to bear for their clean-up?

- what shifts in beach use can be expected over time, as the demographic characteristics of the population change?

- what shifts can be expected as some little-used beaches are made more accessible by improved access or management?

The use of a computerized model to represent spatial behaviour patterns is not new, but has a history of over 20 years behind it (Ellis and VanDoren, 1966). The advantages of modelling are the ability to represent quickly and efficiently the behaviour of a given social/spatial system, and to test various "what if?" questions by changing the parameters of the model and observing the changes in model results.

What is required of such a model is to be able to represent the generation of participants from areas of origin according to demographic and participation data, and then to allocate the flows of participation to specific destinations. Since there can be many hundreds of origins and destinations, a powerful mainframe computer has generally been used. The most popular modelling method has been the gravity model, which requires a basically simple formula to be calculated and recalculated several times, and for constraining totals to be checked at each iteration (Wilson 1974, Vickerman 1974, Ewing 1980).

In this paper, the implementation of a spatial model capable of handling several hundred origins and destinations is described for a microcomputer. In view of their still limited power, innovations were required in both model structure and in the use of application software. It was desired to use an "off-the-shelf" program for the model, and the popular spreadsheet program Lotus 123 was chosen. This choice enabled both simple implementation and easy portability of the model, and also facilitates its wide use since so many non-specialist personnel are familiar with the use of the Lotus 123 program.

3. Model Structure

Swimming at beaches, versus swimming in pools, is associated much more strongly with longer trips and with tourism activity than with short trips made from home. It thus was necessary to distinguish in the model between swimming occasions taking place on a trip which is home-based, where the user starts and ends the day at the home location, and those which are non home-based, where the user is by definition staying away from home for one or more nights. The deterrent effect of, say, a one-

hour travel time to a beach is much greater for a home-based trip than for a non home-based one.

The way this difference in spatial behaviour was handled in the model was to have, in effect, two different gravity models to allocate the origin-destination flows. One model handled the home-based trips and incorporated a relatively high value for the distance weighting parameter. The other handled non home-based trips and used an appropriately lower value for distance weighting.

The demographic and participation data available had some influence on the choice of origin zones. The counties and districts of Ontario (numbering 51 in total) were taken as the best combination of spatial and social representation of origin areas. Their populations are easily obtained from Census and other data, and accurate age breakdowns are available. In this model, six age groupings were used (0-11 years, 12-19, 20-34, 35-49, 50-64, and 65 or over) since participation data were available to this level of detail (OSRD 1976). A finer level of spatial detail, such as one based on municipalities, was not warranted in this case by the level of detail of available participation and swimming use data.

Each of the 51 origin areas was allocated to one of 11 origin regions. These regions formed the origin base for the gravity models. The destination zones were based on the same general spatial structure, but with the Georgian Bay origin zone split into three separate destination zones, in line with the differing characteristics of its sub-units when beach use is being considered. These decisions resulted in the gravity models having a structural base of 11 origin and 13 destination zones. This requires a core matrix size of only 143 cells per gravity model, as compared to a typical application of the gravity model in urban traffic simulation, where a 1000x1000 matrix would not be unusual. The implementation on a microcomputer was made possible largely by this simplification.

The model was required to be useful in predicting swimming use at individual beach locations, however, and there were some 565 of these of interest to decision-makers at the Provincial level, from among the 3300 inventoried beach locations in Ontario. In order to make this allocation possible, the beaches within each destination zone were allocated swimmers according to an "attraction" formula. This formula incorporated data on the following parameters of each beach:

- length and width of dry beach
- width of wet beach
- air and water temperature regime
- relative locational accessibility within zone
- administration of beach
- pollution-caused closures in past three years
- esthetic factors affecting beach use

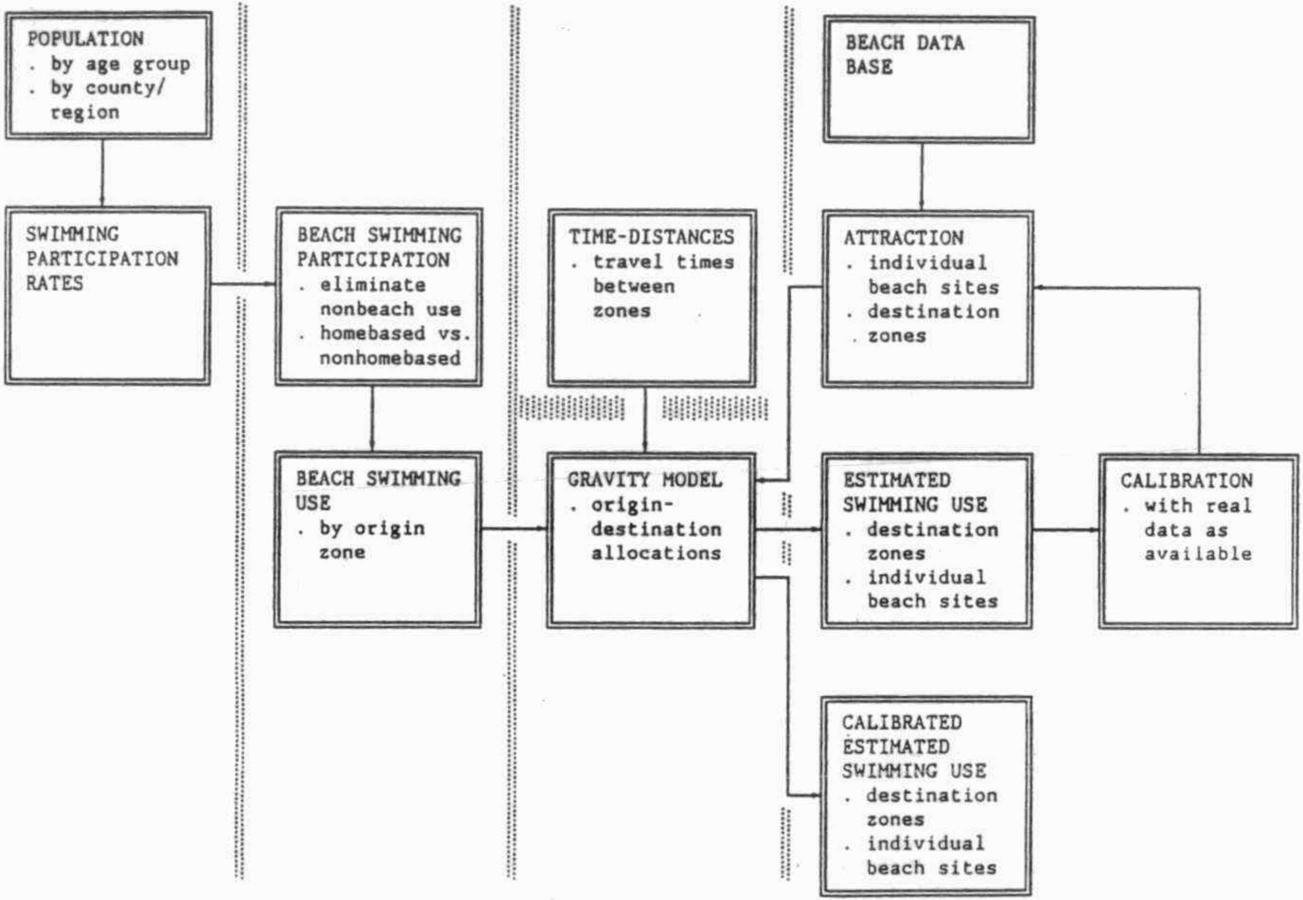
The intra-regional models were implemented by means of a proportional allocation algorithm, which gives a similar result to a gravity model having equal within-zone travel times - although here there were actually six different levels used for the value of relative accessibility within zones. The important factor to note, however, is that the same attraction formulas were used as the basis for the inter-regional "true" gravity models as for the intra-regional allocation models. This is an important requirement so that the whole system model is responsive to any change in parameters for a given beach.

There is much more detail to the implementation of the model than can be discussed in this paper. Those interested in a fuller treatment of the model and its database are referred to the publication <u>Beach Use and Environmental Quality in Ontario</u>, (authored by Anthony Usher, Jack Ellis and Michael Michalski) published in May 1987 by the Policy and Planning Branch of the Ontario Ministry of the Environment, and available from them on request.

Figure 1, on the next page, shows the general structure of the beach use model in graphic form. It should be recalled that the conceptual structure of Figure 1 is actually implemented twice in the Lotus spreadsheet, once for home-based and again for non home-based trips.

It should be noted that the choice of Lotus 123 as the software was by no means automatic. At the outset of the work, it was considered possible that up to 1500 or so beaches might have to be considered in the model, since the Ontario Recreation Supply Index contains about 3300 beach entries, even though it does not cover very much area in northern Ontario. Various database software packages were considered for this large a scale, and the search for a spreadsheet program on which to develop the spatial model settled initially on Microsoft Multiplan. The reason for this choice is that Multiplan can run linked spreadsheets, and it was felt that a large model would have to be run as a linked set of regional models to work on a micro-computer. A prototype three-region model was implemented in Multiplan, but the linked spreadsheets were found to be extremely slow and cumbersome even though the model was of a small size overall (about 50 beaches per region). Disc access in recalculation was the main time consuming factor. It was with considerable relief that the process of elimination of beaches with little or no attendance potential (e.g., beaches under 100 metres in length, gravel or rocky beaches, beaches not road accessible, etc.) from the model reduced the number to the range of 500-600 sites. At this scale, it was quite practical to consider implementing both the database and the model in Lotus 123, and in the end, recalculation time for the whole model is in the order of 2 to 3 minutes on a standard speed PC (4.88 MHz).

FIGURE 1: STRUCTURE OF THE BEACH USE MODEL



4. Model Functioning

The model is a single Lotus 123 spreadsheet, as noted, but has all of the logical structure elements shown in Figure 1. Thus, different portions of the spreadsheet either store basic input data or provide various output results of the model.

On population characteristics, the model contains the population data for each county and region in Ontario, broken down into the six age groups noted earlier. These data are supplemented by:

- o participation rates in swimming, specific to each age group and each of the 11 origin regions
- o fractions of all swimming that is done in a beach environment, specific to each origin region
- o portions of beach swimming done on home-based and non home-based trips, specific to each origin region.

The participation portion of the spreadsheet is designed to give total volumes of beach swimming generated by each origin region, split into numbers of occasions done on home-based and non home-based trips. These results are sensitive to the basic demographics through the population numbers by age groups which can be updated as required, or replaced by any future population projection for test purposes. The participation rates by age groups and region are generated from Ontario surveys (OSRD 1976, OMTR 1981, 1983) which show that swimming participation is somewhat age sensitive and differs a little by origin region, but not to the same extent as some other activities such as cycling or canoeing. These rates appear to be stable over time, but should be tracked once a decade or so, as data become more available. The split of swimming into a "beach" component is based on OSRD 1976 and judgement, since the data source referred to "natural environment" swimming rather than to "beach". There is little likelihood that this split would change much, unless the available supply of pools versus clean beaches changes radically by region in future. The split between home-based and non-home based trips is also based on data from OSRD 1976, which is now rather outdated. There is literature suggesting that recreational trips have shifted to being shorter in length and to fewer overnight trips over the past decade or so, and what the consequences of this are for modelling spatial behaviour (Ellis 1982, Caulkins et al 1985, Christensen et al 1985). This factor can be allowed for in the home/non-home based trip allocations in this model, or in the actual gravity model distribution stages.

The gravity models share one inter-zonal distance matrix, which in this case represents the driving distance in hours between zone centroids. Some of the zones in this model are quite large, spatially, making for some rough approximation to travel from different parts of a zone, but the available data make this

a difficult factor to improve. The origin/destination distribution by the gravity model is done with the origin-constrained version (Wilson 1974), and different matrices are built up for home-based and non home-based trips, using quite different distance weighting functions. A gravity model is usually calibrated by adjusting this distance function (and other parameters) to replicate a known origin/destination matrix. In the case of beach swimming, the full matrix is not known, but origin and destination totals can be estimated from OSRD 1976. This model must be considered to be only crudely calibrated then, until much better data are available.

The total volume of swimming occasions assigned to each destination region is allocated to each beach by a proportional allocation algorithm. This algorithm gives each beach in a region an amount of swimming that is proportional to its share of the region's beach "attraction". Beach attraction is a complex formula which weights and manipulates each beach's physical and environmental parameters (listed in section 3). Most of these parameters will not change over time, such as the length of the beach or its climate regime. But the width of the beach can change, as Great Lakes shoreline users know all too well, and the factors of esthetic or pollution impairment are highly variable. At the present stage, no data are entered in the model regarding esthetic impairment, since no full survey of this has been done in Ontario. The model is ready for such information when it becomes available. Pollution data is gathered from regular measurements done by Health Units for coliform organisms in the water, and this model stores the number of weeks each beach was closed or "posted" for health reasons during the past three years. At present, the model de-rates the attraction of a beach in direct proportion to the average percentage of a season that the beach has been closed in 1983-86. This could be changed to some other measure, if some better assumption on swimmers' perceptions of pollution related to beach posting could be derived, perhaps from a behavioural survey.

Within destination zones, the model is fine-calibrated to replicate attendance data - insofar as they are available - at the individual locations. This information is collected mainly at controlled beach locations, such as in Provincial Parks and Conservation Areas, although some use estimates for beaches at concession road allowances have been made in field checks. This information yields values for a "calibration factor" which is entered in the attraction calculation of the model. At the present stage of development of the model, this aspect is probably the one which would benefit most from improved data, since it is difficult to assess just which aspect of the model's performance is being helped by which adjustment, given the relatively small amount and the scattered spatial nature of the hard data.

The model is quite sensitive to changes in beach parameters, however, showing instant response of user volumes to changes in such factors as pollution clean-up, which is what is was designed to do. Figure 2, below, shows the first few lines of output from a "standard" run of the model, with the given values of existing data. Figure 3a, next page, shows what happens when the pollution is reduced to zero at Toronto Island. It can be seen that Metro Toronto beach use goes up, while nearby beaches all go down, slightly. Figure 3b, next page, shows the effect of adding a new beach (in Scarborough) to the Metro Toronto region. Again, all nearby beaches are affected, in diminishing proportion depending on their distance from the new beach. Hand-written notes on the printouts highlight these differences.

FIGURE 2. PARTIAL MODEL OUTPUT FROM A STANDARD RUN

NAME	ADM.	WET	DRY	E.L.	TEM.	LOC.	AES.	%P.X	ATT.	USE	CC	C.ATT.	C.USE
NORTHWESTERN ONTARIO													
unallocated									205	1299		200	1298
NORTHEASTERN ONTARIO													
unallocated									585	4433		572	4429
METRO TORONTO													
Ashbridge's Bay Pk	M	3	4	348	P	1		39%	13	117	1.0	13	117
Marie Curtis Pk	M	3	4	518	P	1		79%	7	59	1.0	7	60
Sir Casimir Gzowski Pk	M	2	4	872	P	1		81%	10	89	1.0	10	89
Toronto Islands	M	4	4	1849	P	4		40%	24	213	1.0	24	214
Woodbine B	M	3	6	532	P	1		39%	20	178	1.0	20	179
subtotal									74	655		74	659
unallocated = 10.4%									9	76		9	77
total									82	731		82	736
GOLDEN HORSESHOE													
Albert E Crookes Memor	M	3	2	105	P	1			3	26	1.0	3	26
Albion Hills CA	CA	6	5	180	E	3			10	88	1.0	10	89
Bay Beach Corporation	Pr	4	5	152	G	4			0	0	1.0	0	0
Binbrook Dam & CA	CA	2	2	107	E	4			2	16	1.0	2	16
Bruce's Mill CA	CA	5	2	174	E	4		26%	2	19	1.0	2	19
Buffalo Canoe Club	Pr	6	4	137	G	4			0	0	1.0	0	0
Cedar B Pk	C	3	3	152	E	4		7%	1	8	1.0	1	8
Chippawa Cr CA	CA	2	3	135	E	4			4	40	1.0	4	40
Christie CA	CA	3	5	366	E	3			20	179	1.0	20	180
Claireville CA	CA	3	5	150	E	1		33%	11	98	1.0	11	98
Club La Salle	Pr	5	3	380	G	1			0	0	1.0	0	0
Confederation Pk APk	M	3	6	964	P	1		30%	41	379	1.0	41	381
Copetown Holiday Pk Lt	C	4	4	147	E	3			2	14	1.0	2	14
Courtcliffe Pk	C	1	2	122	E	3		33%	0	3	1.0	0	3
Crystal B Pk	C	5	3	229	G	4			1	11	1.0	1	11
Darlington PPk	PPk	2	2	152	P	2			3	28	4.0	12	112

FIGURE 3. PARTIAL MODEL OUTPUT FROM MODIFIED RUNS

40% posting eliminated

attraction index rises from 24 to 40

estimated use rises from 214 to 351

total estimated use for Metro rises from 736 to 879

NAME	ADM.	WET	DRY	E.L.	TEM.	LOC.	AES.	%P.X	ATT.	USE	CC	C.ATT.	C.USE
NORTHWESTERN ONTARIO													
unallocated									205	1299		201	1298
NORTHEASTERN ONTARIO													
unallocated									587	4432		574	4429
METRO TORONTO													
Ashbridge's Bay Pk	M	3	4	348	P	1		39%	13	115	1.0	13	115
Marie Curtis Pk	M	3	4	518	P	1		79%	7	58	1.0	7	58
Sir Casimir Gzowski Pk	M	2	4	872	P	1		81%	10	87	1.0	10	87
Toronto Islands	M	4	4	1849	P	4			40	349	1.0	40	351
Woodbine B	M	3	6	532	P	1		39%	20	175	1.0	20	176
subtotal									89	783		89	788
unallocated = 10.4%									10	91		10	91
total									100	874		100	879
GOLDEN HORSESHOE													
Albert E Crookes Memor	M	3	2	105	P	1			3	25	1.0	3	25
Albion Hills CA	CA	6	5	180	E	3			10	87	1.0	10	88
Bay Beach Corporation	Pr	4	5	152	G	4			0	0	1.0	0	0
Binbrook Dam & CA	CA	2	2	107	E	4			2	16	1.0	2	16
Bruce's Mill CA	CA	5	2	174	E	4		26%	2	19	1.0	2	19

estimated use falls from 214 to 209

New Entry

total attraction index for Metro rises from 82 to 106

total estimated use for Metro rises from 736 to 925

NAME	ADM.	WET	DRY	E.L.	TEM.	LOC.	AES.	%P.X	ATT.	USE	CC	C.ATT.	C.USE
NORTHWESTERN ONTARIO													
unallocated									206	1299		201	1298
NORTHEASTERN ONTARIO													
unallocated									588	4432		575	4429
METRO TORONTO													
Ashbridge's Bay Pk	M	3	4	348	P	1		39%	13	114	1.0	13	115
Bradley Pk	M	3	3	500	P	1		20%	21	183	1.0	21	185
Marie Curtis Pk	M	3	4	518	P	1		79%	7	58	1.0	7	58
Sir Casimir Gzowski Pk	M	2	4	872	P	1		81%	10	86	1.0	10	87
Toronto Islands	M	4	4	1849	P	4		40%	24	208	1.0	24	209
Woodbine B	M	3	6	532	P	1		39%	20	174	1.0	20	175
subtotal									95	824		95	829
unallocated = 10.4%									11	96		11	96
total									106	919		106	925
GOLDEN HORSESHOE													
Albert E Crookes Memor	M	3	2	105	P	1			3	25	1.0	3	25
Albion Hills CA	CA	6	5	180	E	3			10	87	1.0	10	87
Bay Beach Corporation	Pr	4	5	152	G	4			0	0	1.0	0	0
Binbrook Dam & CA	CA	2	2	107	E	4			2	16	1.0	2	16
Bruce's Mill CA	CA	5	2	174	E	4		26%	2	19	1.0	2	19

5. Future Developments

The future development and use of the model is likely to centre on two areas: the improvement of the model with additional data, particularly on individual beach attendance; and the extension of the model to yield economic valuations of the swimming use of each beach. It is also possible to consider modelling the entire array of recreational activities taking place at beaches, in addition to swimming, but this would require a considerable amount of on-site observation to determine what these patterns of activity are at different locations.

The area of economic valuation has an extensive literature, and a few selected references are given in the bibliography. The concept is to determine the economic value of a given recreation experience, in this case swimming at a beach, to the person doing the activity. This value is often used in benefit-cost studies, for example. The value is composed not just of the cost which the user pays out directly, since the access to many beaches is free. It also includes an estimate of what the social consumer surplus value is for that experience, and this must be determined by indirect means. One such method is to derive a "travel cost" estimate by determining the average distance users travel to a given beach, and valuing that travel by the cost of time and distance travelled.

Since this model can provide splits of travel to beaches on home-based and non-home based trips, and the distance distribution for users of each beach can be calculated by further formula manipulation, it does lend itself to such applications with further development.

In any case, this model has shown that a reasonably complex spatial model can be implemented on a standard microcomputer with readily-available software. Perhaps this finding will encourage other applications, and phenomena for which more data are available can yield even more useful experience.

BIBLIOGRAPHY

Caulkins, P.P., R.C. Bishop and N.W. Bouwes 1985 "Omitted Cross-price Variable Biases in the Linear Travel Cost Model: Correcting Common Misconceptions" Land Economics, Vol. 6, pp 482-487.

Christensen, J.B., S.K. Humphries and C. Price 1985 "A Revised Clawson Method: One Part Solution to Multidimensional Disaggregation Problems in Recreation Evaluation" Journal of Environmental Management, Vol. 20, pp 333-346.

Ellis, J.B. 1982 "Energy Costs and the Travelling Public - Future Effects on Canada's Park System" Keynote Paper, Proceedings, Federal-Provincial Park Conference, Halifax N.S., October 1982.

Ellis, J.B. and C.S. VanDoren 1966 "A Comparative Evaluation of Gravity and Systems Theory Models for State-Wide Recreational Flows" Journal of Regional Science, Vol. 6, pp 57-70.

Ewing, G.O. 1980 "Recreational Trip Generation and Distribution Models" Leisure Sciences, Vol. 3, pp 1-24.

McAllister, D.M. and F.R. Klett 1976 "A Modified Gravity Model of Regional Recreation Activity with an Application to Ski Trips" Journal of Leisure Research, Vol 8, pp 21-34.

McConnell, K. 1977 "Congestion and Willingness to Pay: A Study of Beach Use" Land Economics, Vol 53, pp 185-195.

Ontario Ministry of Tourism and Recreation 1981 Physical Activity Patterns in Ontario.

Ontario Ministry of Tourism and Recreation 1983 Physical Activity Patterns in Ontario.

Ontario Secretary for Resources Development 1976 Ontario Recreation Survey. 8 Volume series, Tourism and Outdoor Recreation Planning Study Committee.

Sorg, C. et al 1985 The Net Economic Value of Cold and Warm Water Fishing in Idaho. Ft. Collins, CO; Rocky Mountain Forest Range Experiment Station, Resource Bulletin RM-11.

Usher, A., J.B. Ellis and M. Michalski 1987 Beach Use and Environmental Quality in Ontario. Ontario Ministry of the Environment, Policy and Planning Branch.

Wilson, A.G. 1974 "A Family of Spatial Interaction Models" Environment and Planning, Vol. 3, pp 1-32.

Zalatan, A. 1983 "A Refined Method for Estimating Recreation Benefit" Leisure Sciences, Vol. 5, pp 381-396.

DRAFT

THE TRANSPORTATION OF LIQUID INDUSTRIAL HAZARDOUS WASTE IN ONTARIO

Prepared for the Ontario Ministry of the Environment

by

Ron Thompson with
Norman Mogil and
Arthur Donner

A.R.A. CONSULTANTS
SEPTEMBER 30, 1987

THE TRANSPORTATION OF LIQUID INDUSTRIAL WASTE IN ONTARIO

ABSTRACT

This study describes the economic, financial and structural characteristics of the liquid waste haulage industry in the province. The data sources include Statistics Canada, government reports, trade journals and interviews with selected industry representatives and operators. "Liquid industrial waste" includes all liquids which are subject to Regulation 309, including hazardous liquid wastes.

Approximately, 90% of all revenues were derived from routes in excess of 25 km within the province. The average firm has total fixed assets of $1.4 million, shareholder's equity of less than $500,000, and a debt/equity ration of 3.8, suggesting the industry is small, under-capitalized with a high debt load.

Southwest Ontario accounts for 40% of all tonnage shipped with the west central region accounting for an additional 29%. Average tonnage per firm in the province was 8,971 per year. For the province as a whole, the three largest firms account for 29% of all tonnage and 17% of all shipments.

The transportation of liquid industrial waste is extremely competitive on the basis of price. The price varies due to three key factors: type of materials handled; distance travelled; and nature of the equipment required.

Several of the smaller firms are merging or being bought out in the wake of a general rationalization taking place in transportation and trucking in particular. There is a movement towards more integration into "downstream" operations, ie. disposal sites.

Table of Contents

List of Tables and Figures

THE TRANSPORTATION OF LIQUID INDUSTRIAL WASTE IN ONTARIO: EXECUTIVE SUMMARY

Background

This report examines the economic, financial and structural characteristics of the liquid waste haulage industry in Ontario. The study researches a number of issues such as: size; regional characteristics; degree of integration; financial strength; and the influence of regulatory factors on financial operations. The data sources include Statistics Canada, government reports, trade journals and interviews with selected industry representatives and operators.

Definitions and Regulations Affecting Transportation

Our definition of "liquid industrial waste" includes all liquids which are subject to Regulation 309, including hazardous liquid wastes. The transportation of dangerous wastes is regulated by the federal and provincial authorities. Federally, the Transportation of Dangerous Goods Act (TDG) contains specific requirements for tracking waste by means of shipment manifests, and prescribes safety procedures. The Ontario Dangerous Goods Transportation Act is administered by the Ministry of Transportation and Communications. MOE is responsible for controlling the flow of all wastes under Regulation 309, which establishes a monitoring system from origin to disposal, a registration system for generators, and an approvals system for carriers and receivers of subject waste. According to the MOE data gathered to date, we estimate that about 650,000 to 700,000 tonnes of subject liquid waste is shipped in the province annually.

Financial Analysis of the Industry

Our analysis is based on a special tabulation by Statistics Canada on liquid industrial waste carriers in Ontario in 1985. The carriers in this sample hauled a broad range of commodities in addition to liquid waste.

Approximately 90% of all revenues were derived from routes in excess of 25 km within the province. The average firm has total fixed assets (fully depreciated) of $1.4 million, shareholder's equity of less than $500,000 and a debt/equity ratio of 3.8, suggesting the industry is small and under-capitalized with a high debt load.

Industrial Structure: Operational and Regional Characteristics

Southwest Ontario accounts for 40% of all tonnage shipped with the west central region accounting for an additional 29%. Average tonnage per firm in the province was 8,971 per year.

There is a clear dichotomy with half of the firms registered to do so heavily engaged in hauling liquid industrial waste and the other half hardly at all; this suggests the nature of transporting "specialized waste" products. The specialization required is evident by the fact that the industry must "dedicate" certain equipment for particular types of waste.

Market Concentration and Market Segments

The three largest carriers in each region of the province account for a disproportionately large share of tonnage and total shipments. For the province as a whole, the three largest firms account for 29% of all tonnage and 17% of all shipments. The integrated carriers (firms which both generate and transport waste) account for 53% and 63% of total waste carried in the two biggest regions, the southwest and west central regions. Collectively, the integrated firms carry 10% more waste than they generate and are increasingly moving more "downstream" as they diversify to become operators of disposal or treatment sites.

Transportation Costs and Fees

The transportation of liquid industrial waste is extremely competitive on the basis of price. For generators, the removal of waste without recovery potential is an unproductive cost of doing business and they therefore look to the lowest cost of service, bearing in mind quality (safety) considerations.

Since the industry does not file a tariff, our information on fees must rely on previous studies which indicate that the cost of for-hire haulage can vary from $55.00 to $100.00 per hour. The price may vary due to three key factors: type of material handled; distance travelled; and nature of the equipment required.

There is no valid way of determining what volume of waste in general is "economic" to haul. For some materials the generator will pay the carriers to dispose of waste; for other products, the carriers will pay the generator; it all depends on the market value for the waste product in question. Transportation operators are astute business people who display a high degree of entrepreneurism in their operations.

Other Factors Affecting the Industry

Entry and Exit

No data exists on entry to and exit from the industry hauling liquid industrial waste. Entry is difficult due to the high cost of capital, time required to receive operating licenses, and the need for skilled managers and well-trained operators. Rather than exiting directly from the industry, some firms are merging or being bought out in the wake of a general rationalization taking place in transportation, and trucking, in particular.

Deregulation and Integration

There is a movement toward more integration into "downstream" operations, i.e., disposal sites. This offers the carrier the opportunity of charging both for the haulage and disposal of waste, especially as the number of acceptable disposal sites diminish with time.

1.0 INTRODUCTION

The Government of Ontario has always had an interest in the technical and environmental issues surrounding the transportation of hazardous and other industrial wastes. An important and to date undocumented dimension to the setting of public policy in this area lies in the financial, economic and structural characteristics of the industry, and how these characteristics affect transportation operators. A variety of environmental and safety regulations affect the costs of moving and disposing of industrial waste. These regulations have a fundamental impact upon the industry's profits, rates of return and, possibly, the very nature of the way an individual operator's business is conducted.

The purpose of this study is to determine the economic, financial, and structural characteristics of the liquid waste haulage industry in Ontario. The selection of liquid waste carriers as the exclusive subject of the study raised a number of methodological and data problems which were not apparent initially to either the Ministry of the Environment, or the consultants. In retrospect, the separation of liquid waste carriers from other "subject waste" carriers (see Section 2.0) was not desirable for this particular study. Little enough is known about the structure and operation of subject waste carriers at large to make that more general study preferable to this more specialized study. Nevertheless, this report attempts the most thorough description of the liquid waste transportation sector yet prepared.

This study researches a number of key issues related to the structure and performance of the industry, including:

- o size characteristics;
- o regional characteristics (e.g., how the industry differs in northern regions compared to that in the "golden horseshoe");

- o the extent of vertical integration (i.e., transporters with generators, and with disposal site operators);
- o the financial health of the industry, including profitability and debt/equity levels;
- o the extent of entry to and exit from the industry in recent years;
- o the economic factors which influence decisions to introduce new technology;
- o how fees are determined and how price competitive the industry is; and
- o how provincial and federal environmental and licensing regulations will likely affect financial performance.

1.1 Research Methods

Originally, the terms of reference proposed that the study rely primarily on data collected through interviews with generators and transport operators in the various regions. To this end, we approached the Ontario Trucking Association (OTA) to assist us in collecting data in a survey of a sample of members who specialize in the transportation of liquid industrial waste. A.R.A. met with the OTA's liquid waste carriers' sub-group to explain the study, and found marked and eloquent opposition to it from its members. Apparently, members had previously participated in another study commissioned by a provincial agency and had been displeased with how it had been used.

After a long discussion, the OTA's liquid waste carriers agreed to participate conditionally in our study, and subsequently both provided us with a list of some 32 members, and encouraged their membership to cooperate with us by providing basic information. The data from the questionnaire was to be delivered to the OTA on a confidential basis and the OTA was to aggregate the data so that no specific corporate information would be given

to the consultants. The questionnaire was sent out in April, 1987. Only 3 replies were received by the OTA, and follow-up discussions with OTA staff revealed that for its individual members were very reluctant to provide financial and economic data for this study for the same reasons that the OTA had initially stated.

Accordingly, we were forced to alter our research methods; after meeting with the Ministry of Environment's project Steering Committee to discuss the problems encountered with the survey, it was agreed that we would seek information from the following sources:

- Statistics Canada;
- government reports and original sources within government files;
- private consultant reports;
- articles from trade journals; and
- a limited number of interviews with industry representatives, and operators (where possible) and relevant government officials to corroborate our findings from other sources.

In adopting this approach, we were aware of the spotty nature of data in the public domain (e.g., Statistics Canada), and also that the interviews would contain considerable anecdotal evidence rather than "hard" information. Despite the fact that we were not able to carry out our original questionnaire, we nevertheless believe that the analysis in this report is useful for future policy making.

2.0 DEFINITIONS AND DESCRIPTION OF THE REGULATORY SYSTEM

One of the methodological problems we encountered with this study arose from singling out liquid industrial waste from other "subject" or "manifestable" wastes. The data available on waste quantities does not specify if they are liquid wastes or solid hazardous wastes. Both types are subject to the Ministry of Environment's Regulation 309. Likewise, carrier certification data does not accurately specify the liquid/solid composition of wastes which a carrier or a generator is registered for (see Section 2.1 below). It is apparent from our research that many liquid waste transportation operators also haul solid hazardous (i.e., also "subject waste") commodities. In addition, many are generators themselves, or receivers. (We describe the various segments of the transportation sector later in the report.) In hindsight then, it would have been more appropriate to consider an integrated approach to the generation, transport and treatment of wastes, rather than singling out one aspect of it in isolation.

At this point, it is necessary to define the terms used in this study, and (in the next subsection), to describe in general the provincial system of regulation which affects liquid waste carriers. In the final subsection we describe the "manifest" system for tracking wastes, and estimate the quantity of manifested subject liquid waste handled annually in Ontario.

According to Regulation 309, "subject waste" means liquid industrial waste, and hazardous waste. "Liquid industrial waste" (according to Paragraph 38 of Section 1) means waste that is both liquid waste and industrial waste but does not include:

- o hauled sewage;
- o waste from the operation of a sewage works;
- o waste from the operation of a water works subject to the Ontario Water Resources Act;

- o waste that is produced in any month in an amount less than twenty-five litres or otherwise accumulated in an amount less than twenty-five litres;

- o waste directly discharged by a generator from a waste generation facility into a sewage works subject to the Ontario Water Resources Act or established before the 3rd day of April, 1957 or into a sewage system, as defined in Part VII of the Act;

- o waste that results directly from food processing and preparation operations, including food packing, food preserving, wine making, cheese making and restaurants;

- o drilling fluids and produced waters associated with the exploration, development or production of crude oil or natural gas;

- o processed organic waste; or

- o asbestos waste.

"Hazardous waste" (according to Paragraph 27 of Section 1) means a waste that is a:

- o hazardous industrial waste;

- o acute hazardous waste chemical;

- o hazardous waste chemical;

- o severely toxic waste;

- o ignitable waste;

- o corrosive waste;

- o reactive waste;

- o radioactive waste, except radioisotope wastes disposed of in a landfilling site in accordance with the written instructions of the Atomic Energy Control Board;

- o pathological waste;

- o leached toxic waste; or
- o PCB waste as defined in Ontario Regulation 11/82

and includes a mixture of acute hazardous waste chemical, hazardous waste chemical, hazardous industrial waste, pathological waste, radioactive waste or severely toxic waste and any other waste or material. (Paragraph 27 goes on to list a number of exempted wastes.)

As "subject" wastes are defined, then, it is obvious that some hazardous wastes may be in liquid form. It is thus virtually impossible at this level of study to determine whether a liquid waste hauled by a carrier is classed as a "liquid industrial waste", or a "hazardous waste". Consequently we have utilized a looser definition in our analysis than that included in Regulation 309. We have generally considered all liquids which are subject to Regulation 309. This is convenient for this study because all such liquids require liquid handling equipment (e.g. tankers, vacuum trucks, drums, etc.). In assessing fleet size and structure, the presence of liquid handling equipment is the most telling indicator that a subject waste carrier is a liquid waste carrier.

2.1 Regulatory Framework

The transportation of dangerous waste -- whether solid or liquid -- is regulated by federal and provincial transport of dangerous goods legislation, which was developed subsequent to the near-disastrous Mississauga train derailment in 1979. In 1980, for the first time, regulations covering the handling and transportation of dangerous goods by road, rail, water and air were promulgated under a single law, the federal Transportation of Dangerous Goods Act (TDG).

The TDG Act is administered by Transport Canada. The Act contains specific requirements for the tracking of dangerous goods by means of shipment manifests, which must accompany all dangerous goods. All shipments of either liquid or solid waste (exceeding 5 litres or 5 kg, respectively, this

exemption is granted all dangerous goods) must have such a manifest. The Act also requires the carrier to develop an "Emergency Response Plan" for the particular waste covered by the manifest.

Nine classes of dangerous goods are categorized by the TDG Act. Prescribed safety marks must be visible on all packages, containers, tanks, cylinders and road/rail vehicles, for all shipments of dangerous goods. The Act places responsibility upon the generator/consignor of the waste to ensure that the transporter utilizes the proper markings. It is the transporter's responsibility, however, to ensure that all employees are trained or operate under the supervision of a trained person.

While it imposes a degree of uniformity on the provinces in the way it deals with international and interprovincial movements of dangerous goods, the Federal Act allows for the promulgation of specific provincial regulations covering the transportation within provincial jurisdiction of dangerous goods in general. The Ontario Dangerous Goods Transportation Act, covering highway transportation of wastes, is administered by the Ministry of Transportation and Communications. Its specific terms are identical to federal regulations.

The Ontario Ministry of Environment is responsible for controlling the flow of hazardous and liquid industrial wastes. It's controlling instrument is "Regulation 309 (General -- Waste Management)", issued under the Environmental Protection Act. Regulation 309 clearly lays out the system to control wastes in the province. The main thrusts of the Regulation are:

- establishment of a system to monitor wastes from origin to disposal, via a shipment manifest for all subject wastes; and
- registration requirements for generators, and certification requirements for carriers and receivers of subject wastes.

According to Regulation 309, all subject waste generators, and all the wastes they produce, must be registered with the Ministry of the Environment. All

waste carriers must be certified by the Ministry, and must meet specific performance and driver training requirements. Ministry of Environment officials indicate that there are in excess of 400 certified carriers in Ontario.

Finally, all receivers of liquid industrial and hazardous wastes must be certified to receive those particular kinds of waste. It is the generator's responsibility to ensure that all wastes are shipped by a certified carrier, authorized and equipped for the transport of the specific waste, to a certified receiver, authorized and equipped for the receipt of that specific waste. A shipment manifest documents each transfer. The next section describes Ontario's tracking system in detail.

2.2 The Manifest System and "Subject Wastes": Estimating Liquid Waste Quantities

The means of ensuring cradle-to-grave tracking of dangerous wastes is via the manifest system of documenting waste transfers. Ontario was the first of the provinces to institute such a system provincially. The system it established clearly defines the responsibilities and reporting requirements of all approved waste generators, transporters, and receivers of all specified subject wastes -- i.e., all hazardous wastes (liquid or solid) and all liquid industrial wastes.

All subject wastes must be accompanied by a shipment manifest (see Appendix 1). In theory, the Ministry can track all waste shipments from source to final disposal/treatment. The Ministry has completed computerizing its manifest records and the reality will eventually be close to the theory. At the present time, the Ministry's records contain a wealth of raw data on annual shipments and quantities of waste generated and carried. Table 1 indicates the kinds of wastes handled by carriers in 1986, by destination ("receiver") and quantity. Appendix 2 describes in detail the subject waste classification system used by Ontario. In 1986, 920,951 tonnes of liquid industrial and hazardous wastes were hauled in Ontario.

It is difficult to disaggregate liquids from solids. "Solutions" and "slurries" are classed as liquid waste, while "sludges" or "residues" may or

TABLE 1
QUANTITIES OF LIQUID INDUSTRIAL & HAZARDOUS WASTES
(i.e. Subject Wastes), BY DESTINATION, ONTARIO 1986
(Tonnes)

Waste Class	Landfill	Private Landfill	Incin-eration	WPCP	Transfer Station	Out of Prov.	Reclam-ation	Dust Suppr.	Misc.	Total	% of Grand Total
Acid Solutions	4,118	0	1,783	12,234	15,968	10,212	21,856	360	2,305	68,836	7%
Alkaline Solutions	4,370	5,444	5,472	5,123	5,340	2,386	6,648	20	126	34,929	4%
Aqueous Salts	25,874	3,627	1,671	199	1,386	1,045	111	0	12	33,925	4%
Misc. Inorganic & Mixed Wastes	40,966	7,203	4,355	177,827	18,547	7,163	4,716	0	2,933	263,710	29%
(of which: Leachate)	0	0	0	(174,128)	0	(15)	0	0	0	(174,143)	(19%)
Non-halogenated Spent Solvents	332	0	17,176	1,103	10,137	5,717	21,975	2	78	56,520	6%
Fuels	2,899	562	843	555	1,838	125	1,303	33	112	8,273	1%
Resins & Plastics	1,867	5,536	1,900	119	2,288	186	897	0	2	12,795	1%
Halogenated Organic Wastes	244	6,846	929	0	11,165	1,143	5,673	0	31	26,031	3%
(of which: PCBs)	0	0	0	0	(9,767)	0	(11)	0	(1)	(9,779)	(1%)
Oily Wastes	6,965	11,512	7,625	28,872	40,332	8,643	94,965	19,782	10,401	229,097	25%
Misc. Organic & Mixed Wastes	8,664	7,838	13,515	69,485	3,263	1,718	545	54,250	4,165	163,443	18%
Processed Organic Waste from Transfer Station	42	0	14,251	0	2,641	1,307	413	0	0	18,654	2%
Plant, Animal Wastes	9	85	773	11	1,514	2,277	0	0	1	4,670	1%
Other Wastes	30	0	0	0	1	19	0	0	18	68	0%
Total	96,380	48,653	70,293	295,528	114,420	41,941	159,102	74,447	20,187	920,951	100%
% of Grand Total	10%	5%	8%	32%	12%	5%	17%	8%	2%	100%	

WPCP = Water pollution control plant
Misc. = Unclassified receiver types.

Source: Ministry of Environment, Waste Management Branch, Manifest Information System.

may not be. A "slump test" measures the ability of a waste to flow; if it passes the test it is technically a liquid waste, although it might generally be termed a "sludge" whether it passes or not. Nevertheless, some materials listed in Table 1 are obviously in liquid form. "Oily Wastes (#251 to 254) comprise 25% of all hauled subject wastes. Landfill leachate (#149) comprises 19% of subject wastes. Neither of these wastes pose significant hauling or handling problems, beyond their sheer volumes.

Virtually all leachate is destined for water pollution control plants, while oily wastes are sent to many destinations, reclamation being the most common end use. Other obvious liquid wastes are acid and alkaline solutions (#111 to 114, and 121 to 123), which together account for 11% of subject wastes, and spent solvents and fuels (#211 to 213 and 221-222) which account for 7% of wastes. These liquids alone total 62% of all subject wastes. If only part of the remaining wastes are liquid, we can estimate that about 70-75% (650,000 to 700,000) tonnes of subject waste transported in Ontario are in liquid form. This estimate differs from that by Proctor and Redfern in 1982.* Our estimate is for <u>shipped</u> waste; in addition, subject waste definitions, waste classes and reporting requirements have changed since 1982.

This estimate is corroborated by examination of the destination of wastes. The most common receivers of wastes are water pollution control plants (32% of wastes); if all wastes which are reclaimed or used in dust suppression (17% and 8%, respectively) are in liquid form, and only part of the remaining wastes are as well, we can assume that the estimate of 650,000 to 700,000 tonnes/year of transported subject liquid waste is valid.

---

* Proctor & Redfern, 1982. <u>Waste Quantities Study</u>. Prepared for Ontario Waste Management Corporation.

A few additional observations need to be made about Table 1: although 920,951 tonnes of subject waste were hauled, this does not represent the actual amount originally generated in Ontario, for a number of reasons:

- the "transfer station" column constitutes a double entry because wastes received at a transfer station are counted as originating at that station when they are ultimately shipped to their final destination;
- wastes originating out-of-province but destined for disposal/treatment in Ontario are covered by shipment manifests; and
- significant quantities of subject waste are disposed of on the generator's site; such wastes must still be registered as subject waste, even though a carrier is not engaged in transporting it off-site.

This latter point is explained by Figure 1. In this study, the carriers we examined are engaged only in hauling off-site as per waste streams 3, 6 and 7. Only these transfers must be documented by a manifest.

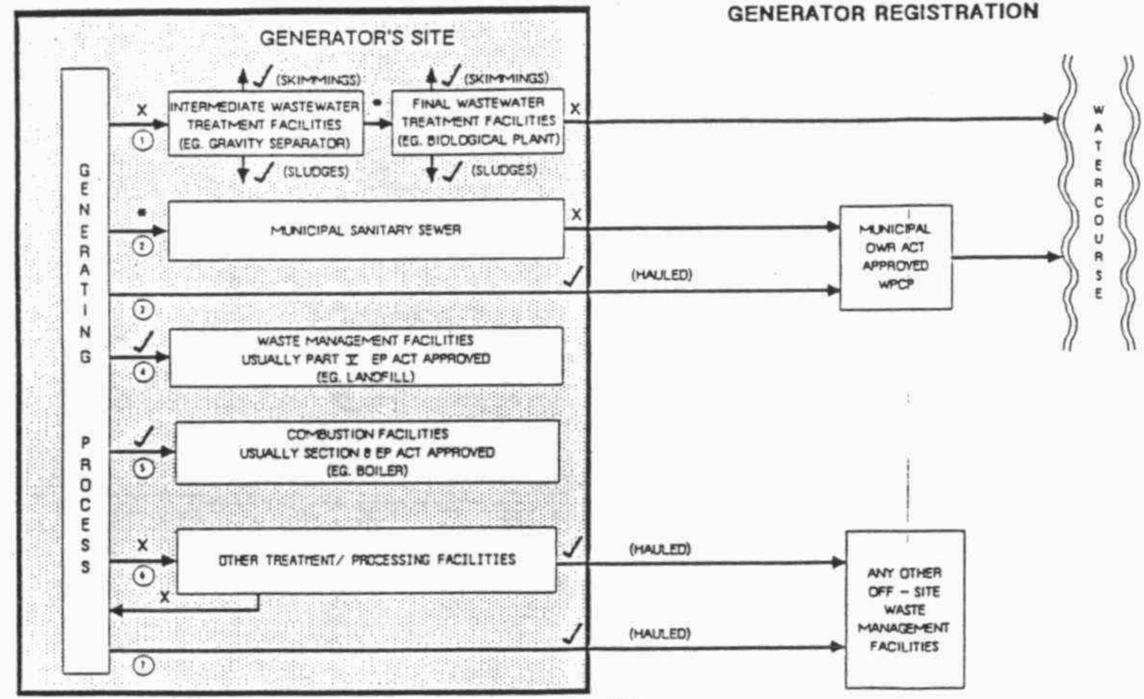
3.0 FINANCIAL ANALYSIS OF THE INDUSTRY

This section outlines our findings as to the financial and economic state of the liquid waste transfer industry. It begins with a general overview of motor carriers in Ontario, followed by analysis of a sample of known subject and liquid waste carriers.

3.1 Overview of Motor Carrier Financial Statistics

In Tables 2 and 3, we present overall financial data for both bulk liquid carriers and all "other" carriers, as defined by Statistics Canada. Bulk liquid carriers include liquid petroleum products and refrigerated liquid products (e.g., milk). We include them here because Statistics Canada indicated to us that some liquid waste carriers inadvertently place

WASTE STREAMS REQUIRING GENERATOR REGISTRATION



X – No Registration Required
✓ – Hazardous, LIW, & RSW Registration Required
* – Only Hazardous Waste Registration Required

WPCP – Water Pollution Control Plant
LIW – Liquid Industrial Waste
RSW – Registerable Solid Waste

NOTE:
Small quantity exemptions apply to all of the above situations. Any of the above on-site management facilities producing wastes (sludges, skimmings, etc.) become generating facilities and resulting wastes may be subject to registration based on destination.

TABLE 2

SUMMARY STATISTICS ON "BULK LIQUID" CARRIERS AND "OTHER" CARRIERS IN ONTARIO - 1985

Revenue Class	Total Assets ($ mill.)	Total Liabilities ($ mill.)	Total Equity ($ mill.)	Average Equity Per Firm of Return on Assets ($ thou.)	Average Rate of Return On Assests* (%)
Bulk Liquid Carriers					
Over $2,000,000	41.8	19.8	21.9	$2,190	15.07%
$500,000 - 1,999,999	23.5	11.9	11.6	464	11.49
$100,000 - 499,900	16.0	8.4	7.6	99	15.19
Total	81.3	40.1	41.1		
Other Carriers					
Over $2,000,000	271.5	199.7	71.9	1,179	11.79
$500,000 - 1,999,999	86.5	60.1	26.4	293	5.66
$100,000 - 499,000	25.7	18.3	7.4	34	24.12
	383.7	278.1	105.7		

*Net operating income divided by total assets.

Definition of "Bulk Liquid": liquid petroleum products and refrigerated liquid products.
Definition of "Other": agricultural products, dry bulk, mine ores and liquid industrial waste.

Source: Statistics Canada, unpublished data obtained from Transport Division.

TABLE 2

SUMMARY STATISTICS ON "BULK LIQUID" CARRIERS AND "OTHER" CARRIERS IN ONTARIO - 1985 (Continued)

Revenue Class	No. of Firms Reporting	No. of Employees	Total Revenues ($mill.)	Total Expenses ($mill.)	Average Revenue Per Firm ($'000)	Average Expenses Per Firm ($'000)	Average Operating Net Income Per Firm ($'000)
Bulk Liquid Carriers							
Over $2,000,000	10	697	69.6	63.3	$6,960	$6,330	$ 630
$500,000 - 1,999,999	25	433	25.9	23.2	1,036	928	108
$100,000 - 499,000	77	328	18.2	15.77	236	205	32
Total	112	1,448	$113.7	$102.27			
Other Carriers							
Over $2,000,000	61	5,122	$521.7	$489.7	$8,552	$8,028	$ 525
$500,000 - 1,999,999	90	1,317	99.9	95.0	1,110	1,056	54
$100,000 - 499,000	217	1,025	64.5	58.3	297	269	29
Total	368	$7,464	$686.1	$643.0			

Definition of "Bulk Liquid": liquid petroleum products and refrigerated liquid products.
Definition of "Other": agricultural products, dry bulk, mine ores and liquid industrial waste.

Source: Statistics Canada, unpublished data obtained from Transport Division.

themselves in this category. If spotted by Statistics Canada, these firms are reclassified as "other"; some are not spotted. In addition, bulk liquid carriers require specialized fleets similar in some characteristics to those of liquid waste carriers. The "other" carrier class includes auto carriers, agricultural commodities, building materials, mine ores and non-specified commodities; the latter category includes industrial liquid waste carriers.

The data are arranged according to the basic revenue classes:

- o Class 1: over $2 million in annual revenues;
- o Class 2: $500,000 - 1,999,999 in annual revenues;
- o Class 3: $100,000 - 499,000 in annual revenues.

Turning to Table 2, we see that the majority of bulk liquid carriers (77 of a total of 112 reporting firms) have revenues of between $100,000 to $499,000. The average net operating income in this revenue class is $32,000 in 1985, compared to $108,000 for Class 2 and $630,000 for Class 1. Similarly, Class 3 firms, on average, have equity equalling only $99,000, compared to average equity capitalization of $464,000 for Class 2 and $2,190,000 for Class 1.

As for the category of "other" carriers, the majority of carriers (some 217 of a total of 368) are in the lowest revenue and equity capital grouping. On average, the firms in the "other" carrier class have lower operating incomes and much lower capitalization than those firms included in bulk liquid carriers category. "Other" Class 3 carriers have an average operating income of only $29,000 per firm, and possess only $34,000 per firm in equity; the same relationships between the two carrier categories exist with respect to Class 1 and 2. In sum, the bulk liquid carriers are somewhat more prosperous in terms of operating income and capitalization than their counterparts in the "other" carrier category.

Using the same revenue classes, Table 3 sets out an analysis of the expenses for both bulk liquid and "other" carriers. Each major expense category is measured as a percentage of total expenses incurred. Thus, in the case of bulk liquid carriers, for the Class 1 (i.e., revenues over $2 million) transport expenses (e.g., trucks, fuel, driver wages) accounted for only 61 percent of total costs, the lowest percentage cost of all three classes. This suggests that the largest carriers are able to achieve certain economies of scale with respect to transport expenses and thereby possess a certain competitive advantage over the small carriers. Class 1 carriers have the highest maintenance expense and terminal expenses, 17 percent and 5 percent, respectively, but have the lowest overhead expenses, only 17 percent. The higher expenses reflect the fact that many of the larger carriers own and operate their own maintenance and terminal facilities.

With regard to the "other" carrier category, the largest revenue group, Class 1, has higher direct transport costs compared to the smallest revenue carriers (Class 3) and have comparable maintenance expenses. The advantages that the Class 1 carriers have reside in lower administrative costs per unit of expenditure. Thus, in the case of "other" carriers there does not seem to be a clear advantage to the larger operations as is the case with the bulk liquid carriers.

3.2 The Liquid Industrial Waste Transportation Sector in Ontario: Results of a Statistics Canada Survey

A.R.A. Consultants requested a special tabulation by Statistics Canada on liquid industrial waste carriers in Ontario for 1985, the latest year data was available at the time of preparing this report. The data was compiled from the Motor Carrier Freight (MCF) survey carried out in 1986. From its sample of all motor carriers in the province, Statistics Canada compiled data for 10 carriers which A.R.A. had identified as "subject waste" and liquid waste carriers from:

- o the Ministry of Environment's listing of the top 100 carriers of subject waste, in terms of tonnages carried; and

TABLE 3

DISTRIBUTION OF EXPENSES FOR BULK LIQUID AND OTHER CARRIERS IN ONTARIO, 1985

Revenue Class	Total Expenses ($mill.)	Distribution of Expenses As A Percentage of Total Expenses: Transport Expenses (%)	Maintenance Expenses (%)	Terminal Expense (%)	Administration & General Expenses (%)	Total Expenses (%)
Bulk Carriers						
Over $2,000,000	$63.3	61%	17%	5%	17%	100%
$500,000 - $1,999,999	23.1	66	12	1	21	100
$100,000 - $499,000	15.8	63	9	1	27	100
Other Carriers						
Over $2,000,000	489.7	67	10	5	18	100
$500,000 - $1,999,999	95.0	67	12	1	20	100
$100,000 - $499,000	58.3	64	10	1	25	100

Source: See Table 1.

o OTA's listing of members of its liquid waste carriers subcommittee.

These ten firms accounted for 30% of all manifested wastes in Ontario, and more than 20,000 waste shipments.

Because A.R.A. supplied Statistics Canada with a list of 47 firms it was surprising that only these ten were covered by the MCF survey. The other 37 had revenues which were lower than StatsCan's lowest reporting category (for for-hire carriers), or had fewer than 15 vehicles (for private carriers)*. This seems to indicate that the majority of Ontario's registered waste carriers are quite small in comparison to the trucking industry in general. The vast majority of the 400 certified carriers in Ontario are either very small or involved in subject waste haulage as a sideline to their other activities.

The carriers in this sample indicated that they hauled a broad range of commodities in addition to subject or liquid waste. Seven hauled oil or petroleum products/wastes in addition to liquid wastes, aggregate or road salts. Two others operated dump trucks for the transport of solids, and a third hauled solid and other, unspecified wastes.

In terms of the area of operations, all ten of the carriers in this sample operate in Ontario and Quebec; five carriers also transport into the United States. With regard to revenue sources:

o approximately 90% of revenues are derived from routes in excess of 25 km for for-hire carriers; the private carriers in the sample showed higher revenues from local (less than 25 km) routes;

o 90% of for-hire carrier revenues are earned from transport within Ontario's borders; and

o only one company earned as much as 15% of its revenue from U.S. routes, the other carriers had insignificant earnings from the United States.

*These terms are defined in the glossary.

3.2.1 Financial Performance Data

The Statistics Canada sample provided useful information on the financial aspects of the industrial waste carriers in the province; this data is presented in Tables 4 through 7.

Table 4 presents balance sheet information on the 5 for-hire carriers in the sample; no data was collected by Statistics Canada for the private carriers. For-hire carriers collectively employ $11.6 million in assets and have an equity base of $2.4 million. Overall, the sample group has a debt-to-equity ratio of 3.8. Table 5 confirms that 86% of revenues are earned in long distance haulage (more than 25 kilometres) 12.2% in local transport (less 25 kilometres) 12.2% in local transport (less than 25 kilometres).

More revealing is the balance sheet estimates for the average firm in this sample. The average firm has total fixed assets (fully depreciated) of $1.4 million, and shareholders equity of less than a half-million dollars. That is, the sample suggests that the industry is relatively small, under-capitalized, and has a high debt-to-equity ratio.

Table 6 presents analysis of operating expenses in the industry for both for-hire carriers and private carriers. In the case of for-hire carriers, the single most important expense is the purchase of transportation equipment (including rental equipment), comprising some 37.5% of all costs, the next largest expenses in descending order are those for salaries (15%), fuel (13.1%) and then maintenance costs (12.3%). The comparison with private carriers cannot be readily made since several important expense categories are lumped together.

Finally, Table 7 presents before profit and tax data. The most significant observation concerns the fact that profits as a percentage of total assets averaged 9.4% for the sample during 1985.

TABLE 4

BALANCE SHEET FOR SAMPLE OF LIQUID INDUSTRIAL

WASTE CARRIERS IN ONTARIO, 1985

	Total Sample ($000)	Average Per Firm ($000)
	Sample Size = 5	
Assets		
Current Assets	$ 4,616	$ 923.2
Fixed Assets		
Land	61	12.2
Building	478	95.6
Revenue Equipment	11,852	2,370.4
Other Equipment	143	28.6
Shop	181	36.2
Furniture	44	8.8
	69	13.8
Total	12,828	2,565.6
Less Depreciation	5,854	1,170.8
Total Fixed Assets	6,974	1,394.8
TOTAL ASSETS	$11,590	$2,318.0
TOTAL LIABILITIES	$ 9,175	$1,835.0
TOTAL EQUITY	$ 2,415	$ 483.0

Source: Statistics Canada Transportation Division, Motor Carrier Freight Survey (1985) (unplublished).

TABLE 5

ANALYSIS OF REVENUE SOURCES FOR SAMPLE OF

LIQUID INDUSTRIAL WASTE CARRIERS IN ONTARIO, 1985

	For-Hire Carriers ($000)	(%)
	Sample Size = 5	
Revenue Source		
Local	$ 3,337	12.3
Long Distance	23,582	86.6
Storage	0	0
Equipment Rental	306	1.1
Total Operating Revenue	$27,225	100.0

Source: Statistics Canada Transportation Division, Motor Carrier Freight Survey (1985) (unpublished).

TABLE 6

ANALYSIS OF OPERATING EXPENSES FOR

SAMPLE OF LIQUID INDUSTRIAL WASTE CARRIERS IN ONTARIO, 1985

	For-Hire Carriers		Private Carriers	
	($000)	(%)	($000)	(%)
	(Sample Size = 5)			
Salaries	$ 3,869	15.0%	$ 5,577	32.4%
Fuel	3,379	13.1	2,492	14.5
Tires	711	2.8	*	*
Purchased Transport Equipment	9,690	37.5	*	*
Other Equipment	59	0.2	*	*
Vehicle	367	1.4	795	4.6
Depreciation	1,290	5.0	2,901	16.8
Subtotal	19,365	75.0	n.a.	n.a.
Maintenance	3,172	12.3	2,871	16.7
Terminal Costs	272	1.1	n.a.	*
Traffic and Sales	314	1.2	n.a.	*
Insurance	415	1.6	**	*
Administration	2,283	8.8	n.a.	n.a.
Total Operating Costs	$25,821	100.0%	$17,232	100.0%

*Included in maintenance costs.
**Included in vehicle license costs.

Source: Statistics Canada Transportation Division, Motor Carrier Freight Survey (1985) (unpublished).

TABLE 7

NET OPERATING REVENUES, PROFITS AND TAXES FOR

SAMPLE LIQUID INDUSTRIAL WASTE CARRIERS IN ONTARIO, 1985

	For-Hire Carriers ($000)	Average Per Firm ($000)
	Total Sample = 5	
Net Operating Income From Motor Carrier Freight	$1,439.0	$287.6
Profit	1,090.0	218.0
as a Percentage of Total Assets	9.4	
Corporate Income Tax	295.0	59.0
Retained Earnings	795.0	159.0

Source: Statistics Canada Transportation Division, Motor Carrier Freight Survey (1985) (unpublished).

3.2.2 Comparative Analysis

In order to provide some perspective on the financial performance of the liquid industrial waste haulers, in Table 8 we compare some key financial ratios among the basic segments of the transportation industry. The "transportation sector" data includes all forms of transportation, air, rail, road and water, and is presented for the purposes of providing some type of benchmark for comparison purposes. A more specific benchmark is the performance of large trucking corporations, such as Laidlaw Transportation and Trimac, both of whom haul subject wastes among many other commodities.

According to the data in Table 8, the transportation sector as a whole in 1986 had a return on capital of 10.7%, whereas Laidlaw greatly exceeded that performance (20.2%) and Trimac fell short (7.8%). The firms in our small sample of industrial waste carriers fared relatively well, recording a return on capital of 9.4% for 1985, the latest year data is available.

As for operating margins, the sample firms registered margins of 5.2%, somewhat below the overall transportation sector average (7.9%). Where the sample firms suffer the most in comparative terms is with respect to their average debt/equity ratio. These firms operate with a very high debt/equity ratio of 3.8, compared to an industry-wide average of 1.53 and well above the average for Laidlaw (0.39) and Trimac (1.6). This suggests that the firms in our sample are seriously hampered in expanding operations for lack of internal sources of capital; adding further debt for expansion purposes (or to meet more stringent equipment or operating standards) would reduce further the relative low operating margins and overall profitability. It must be emphasized, too, that the sample of firms for which we have financial data represents the large firm segment of subject/liquid waste carriers. We can expect the small operators to face similar or more severe debt loads because of the significant capital requirements of operating as a carrier.

In this same context, the under-capitalization of the industry, especially those in our sample, suggest that it would be financially difficult for much of the industry to meet yet higher environmental and safety hazards. The degree of difficulty can only be determined on a case-by-case basis.

TABLE 8

COMPARISON OF FINANCIAL RATIOS FOR

TRUCKING INDUSTRY AND LIQUID INDUSTRIAL WASTE CARRIERS

	Return on Capital	Operating Margin (%)	Debt/Equity Ratio
Transportation Sector	10.65%	7.98%	1.53%
Public Trucking Corporations (1986):			
Laidlaw Transportation	20.18	14.8	0.39
Trimac	7.81	5.0	1.6
A.R.A. Study Sample (1985)	9.4	5.16	3.8

Definitions:

Return on Capital: Net Income before interest and income taxes divided by total debt and total shareholders' equity.

Operating Margin: Operating profit (operating revenue less operating expenses divided by total operating revenues.

Debt/equity ratio: Total debt divided by total shareholders' equity.

Source: For transportation sector, see "Report on Business Magazine" July, 1987, Globe and Mail (Toronto)
For A.R.A. study sample, see Tables 4, 5, 6 and 7.

4.0 INDUSTRIAL STRUCTURE: OPERATIONAL AND REGIONAL CHARACTERISTICS

In this section we examine the structure of the industry which hauls subject waste from several related perspectives:

- volumes and regional configuration;
- diversification vs. specialization;
- fleet characteristics and;
- operational characteristics.

4.1 Subject Waste Tonnage by Region

Table 9 illustrates the regional characteristics of registered carriers of manifested or "subject" waste". Using Ministry of the Environment data, the 100 largest firms (by tonnage) accounted for 897,141 tonnes in 1986 -- or some 97% of all subject waste shipped in the province that year. These 100 firms were grouped according to the Ministry of Environment region in which they are registered (Map 1 Because there are few carriers in either the Ministry's Northeastern or Northwestern Regions, we have combined both as the "Northern" Region for the purposes of this analysis). Subsequent analysis assumed that their operations were predominantly within the region in which they are "domiciled" (registered). This is a bold assumption because many carriers operate between regions or make shipments from across the province to specialized receivers and reclamation facilities (such as Breslube's Breslau operation) or disposal sites (such as Tricil's incinerator at Sarnia). Nevertheless, the head office location is in most instances a good indicator of the center of a carrier's operation, and of its regional concentration of operations. It is also a good indicator of the regional structure of industries which produce subject wastes. (In any event, head office location is the only indicator readily available from Ministry records which facilitates this level of analysis.)

Indeed, most subject wastes not destined for specialized use or disposal are transported the minimum distance possible -- i.e., to the closest certified landfill, water pollution control plant or other treatment facility or end use. Based on the destinations of manifested subject wastes indicated previously in Table 1, we estimate that in excess of 60% of subject wastes

TABLE 9

CHARACTERISTICS OF THE 100 LARGEST (BY TONNAGE) LIQUID & HAZARDOUS INDUSTRIAL WASTES CARRIERS IN ONTARIO, BY M.O.E. REGION, ONTARIO, 1986

MOE REGION IN WHICH FIRM IS REGISTERED:

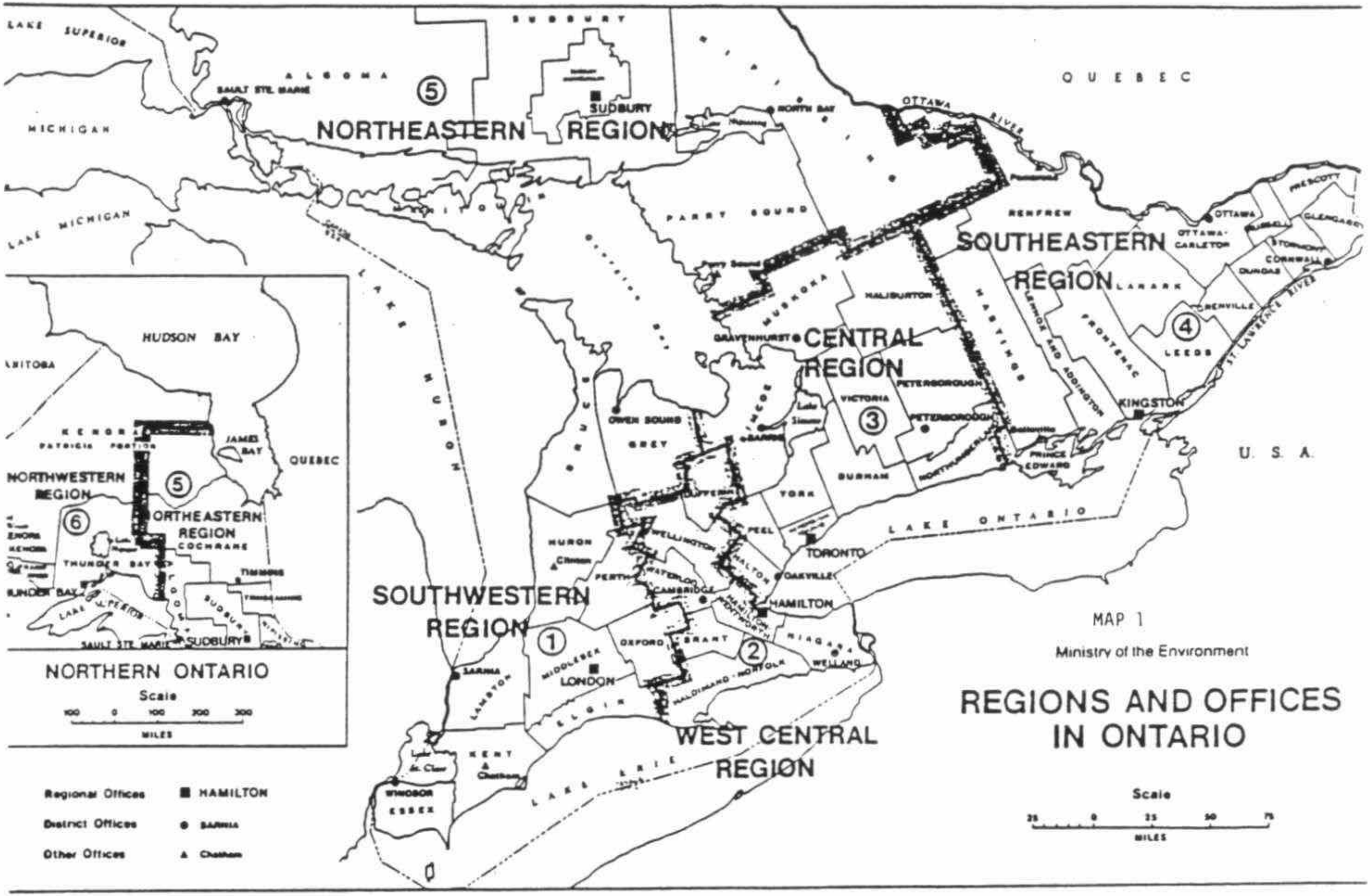
	Southwest	West Central	Central	Southeast	Northern*	Total Ontario
Number of Firms	28	24	28	15	5	100
Total Subject Waste Transported (tonnes)	361,498	257,093	215,722	55,229	7,599	897,141
Total Number of Shipments	22,376	19,300	25,200	3,473	450	70,799
Averages:						Average:
- Tonnes/Firm/Year	12,911	10,712	7,704	3,682	1,520	8,971
- Tonnes/Shipment	16	13	9	16	17	13
- Shipments/Firm	799	804	900	232	90	708

*Because there are few large liquid waste carriers in either of MOE's Northeastern and Northwestern Regions, we have for the purposes of this report combined the two regions as "Northern".

"Number of shipments" refers to the number of wastes indicated on the MOE manifest. See accompanying text.

Source: Manifest data from Ontario Ministry of Environment.

MAP 1



LAKE SUPERIOR
ALGOMA
SUDBURY
SAULT STE. MARIE
SUDBURY
5
NORTHEASTERN REGION
NORTH BAY
QUEBEC
OTTAWA RIVER
MICHIGAN
LAKE MICHIGAN
PARRY SOUND
RENFREW
OTTAWA
PRESCOTT
OTTAWA-CARLETON
SOUTHEASTERN REGION
LANARK
HALIBURTON
MUSKOKA
HASTINGS
LENNOX AND ADDINGTON
FRONTENAC
4
LEEDS
GRENVILLE
CORNWALL
DUNDAS
ST. LAWRENCE RIVER
GRAVENHURST
CENTRAL REGION
VICTORIA
PETERBOROUGH
3
KINGSTON
PRINCE EDWARD
U. S. A.
LAKE HURON
BRUCE
OWEN SOUND
GREY
SIMCOE
BARRIE
DUFFERIN
DURHAM
YORK
NORTHUMBERLAND
LAKE ONTARIO
HURON
WELLINGTON
PEEL
TORONTO
PERTH
WATERLOO
HALTON
OAKVILLE
CAMBRIDGE
HAMILTON
HAMILTON WENTWORTH
SOUTHWESTERN REGION
1
OXFORD
BRANT
2
NIAGARA
WELLAND
MIDDLESEX
LONDON
HALDIMAND-NORFOLK
SARNIA
LAMBTON
ELGIN
WEST CENTRAL REGION
KENT
Chatham
Lake St. Clair
WINDSOR
ESSEX
LAKE ERIE
HUDSON BAY
JAMES BAY
KENORA
PATRICIA PORTION
NORTHWESTERN REGION
6
NORTHEASTERN REGION
COCHRANE
THUNDER BAY
SAULT STE MARIE
SUDBURY
NORTHERN ONTARIO
Scale
100 0 100 200 300
MILES
Regional Offices ■ HAMILTON
District Offices ● SARNIA
Other Offices ▲ Chatham
MAP 1
Ministry of the Environment
REGIONS AND OFFICES IN ONTARIO
Scale
25 0 25 50 75
MILES

are local wastes requiring no specialized treatment and hence no inter-regional movements. A large proportion of the remainder would require specialized treatment (e.g., processing at a reclamation plant, etc.) but such facilities are generally available locally (within the region) because local industries regularly produce such wastes in quantities warranting a local treatment and disposal facility; some such wastes are shipped inter-regionally to specific sites. This leaves a relatively small amount of waste which poses special problems in local disposal, necessitating inter-regional (or interprovincial) shipment or indefinite storage (e.g. in the case of PCBs, and other hazardous wastes.) There are only two hazardous waste incinerators in Ontario--Tricil at Sarnia, and a small incinerator owned by Syntath Division of Tricil, at Thorold. Neither incinerator can dispose of PCBs.

In examining the data in Table 9 (and subsequent tables based on the same source) the reader should bear in mind that the "number of shipments" refers to the number of wastes indicated on the MOE manifest form. Up to four subject wastes may be indicated on each manifest, which covers (in most cases) only one vehicle. While the actual number of shipments (vehicle trips) may thus be less than the number of wastes shipped (as indicated by manifest data), MOE sources indicate that there is usually only one waste per manifest. We have therefore assumed this to be the case in this analysis.

Regionally, southwest Ontario accounts for 28 of the 100 firms and 40% of all tonnage shipped; the next most important region is west central Ontario, accounting for 24 firms and 29% of all shipments.

In terms of size of operations, average tonnage per firm per year was highest in the southwest (12,911 tonnes), followed by the firms in the west central region (10,712); the provincial average was 8,971 tonnes per firm. The central region had the highest number of shipments per firm (900), but only the third highest tonnage per firm (7,704 tonnes), indicating that the average load per firm in this region is lower than in the southwest or west central regions.

Significantly, the five northern operators, reflecting the absence of heavy industry in the north, haul only 1% of the province's subject waste.

4.2 Diversification or Specialization by Liquid Industrial Waste Carriers

In Table 10, we consider a sample of 44 subject waste carriers selected on a random basis from carrier certification records at the Ministry of the Environment. As it happens, the sample selected provide a better indication of the characteristics of the small firm segment of the business than either the special Statistics Canada tabulation or the list of the top 100 carriers examined previously. Indeed, only six of the 44 firms in this sample are on the list of the top 100 carriers (by tonnage) in Ontario.

In considering the measure of liquid industrial waste carried as a percentage of total wastes carried, we find some interesting results. Nearly half of the firms (21) reported being engaged 50% or more in moving liquid industrial waste. There is a clear dichotomy in the industry in the sense that approximately half of the firms in this sample are heavily engaged in hauling liquid industrial waste and the other half is hardly involved at all. This corroborates the Pilorusso and Associates 1983 findings* about the diversity of operations of "special waste" carriers.

4.3 Fleet Characteristics

The Pilorusso report on the "special waste" transportation industry (1983) describes the basic fleet units in use for waste transportation in Ontario. The four basic types of equipment are:

- straight tank trucks
- tractor/tank trailer combinations;
- lugger trucks; and
- straight dump trucks.

---

* Pilorusso Research Associates, Transportation of Special Wastes in Ontario, (OWMC, 1983), p. 57

TABLE 10

CHARACTERISTICS OF A SAMPLE OF REGISTERED CARRIERS
BY REGION

MOE REGION IN WHICH FIRM IS REGISTERED:

	Southwest	West Central	Central	Southeast	Northern	Total
Sample	10	8	9	7	10	44
Location	Local - 7 USA - 3	Local - 7 USA - 1	Local 9	Local 6 Quebec 1	Local 9 USA 1	Local - 38 USA - 5 Quebec - 1
Liquid Industrial Waste as % of Total Waste Carried						
# of Firms With						
0 - 10%	5	2	5	3	1	16
11 - 49%	1	1	1	0	4	7
50 - 89%	2	1	0	1	2	6
90 -100%	2	4	3	3	3	15
Frequency of Collection, Industrial Wastes:						
Daily	4	3	2	2	1	12
Weekly	2	1	1	0	0	4
On Call/As Required	3	1	5	3	4	16
Other (Specify)	-	1 (Emerg.)	1 (no ind.)	1 (no ind.)	1 (spill clean up)	4

Source: Carrier Registration files, Ministry of the Environment

The latter two types of equipment are used for the transport of solid wastes or for partially dewatered liquid wastes. Pilorusso surveyed forty Ontario carriers as to fleet composition, and found their fleets composed largely of tank units "as they were primarily engaged in the transportation of liquid industrial wastes." (p. 71) The study also found that less than 1% of waste shipments were made in drums. Drums are problematic to handle in comparison to pumped waste, and are often used only for the most problematic wastes and for very small shipments.

Table 11 describes Pilorusso's major findings concerning fleet compositions, capacities, etc. The reader is referred to Section 5.4, pages 68-76, of the Pilorusso report, which provides a detailed discussion of factors behind the predominance of certain types of equipment/practices.

For the current study, A.R.A. received information on the fleet structure of the sample of 10 for-hire and private carriers (Table 12) for which Statistics Canada made a special tabulation (see Section 3.2 above). These firms are all large transportation operators in comparison to the majority of registered carriers in Ontario.

Interestingly, these firms overwhelmingly own their fleet units, instead of leasing them. The Ontario Trucking Association confirmed that liquid waste transportation and handling equipment is particularly specialized, so that leased equipment is not readily available on the market. This equipment must often be "dedicated" for particular types of liquid waste alone.

From Table 12, it is obvious that these large firms transport a considerable quantity of non-liquid commodities in addition to liquids. This is true for smaller firms as well; firms in the sample of 44 randomly selected carriers (referred to in Section 4.2 -- selected from MOE carrier certification records) carry a wide variety of commodities. Most are small operators; most

TABLE 11

SUMMARY OF
TRANSPORTATION EQUIPMENT
USED BY CARRIERS SURVEYED
BY PILORUSSO RESEARCH ASSOCIATES (1983)*

TYPE OF UNIT	NUMBER	NOTES
Bulk Liquid:		
Straight Tank Trucks	126 (all carbon steel tanks)	- capacity 3,600 - 18,900 l. (400-4,200 gal.) - 78% between 10,800 and 15,000 l. - largest and smallest tanks are dedicated. - all equipped with vacuum equipment. - 3 vehicles have lined tanks.
Tank Trailer	Total: 121 Comprised of: - 62 carbon steel - 44 stainless steel - 15 aluminum	- capacity 9,000 - 45,000 l (2,000 - 9,000 gal.) - 62% smaller than 25,000 l. - 23% equipped with independent vacuum system. (These without either have a vacuum system in the tractor, or use the generator's.) - 17 carbon steel tanks, and 2 stainless steel tanks, are lined; 2 stainless steel tanks are insulated.
Other Vehicles:		
Lugger trucks	8	
Lugger trailers	3	
Dump trucks	4	
Other Non Bulk Liquid Equipment and Vehicles:		
Straight trucks:		
Vans	4	
Stakes	4	
Trailers:		
Vans	21	
Flatbeds	8	
Tractors	76	

*The Pilorusso study surveyed 40 liquid waste carriers, identified from MOE waybills. These carriers accounted for 83.3% of liquid industrial waste moved on MOE waybills in Ontario in 1982.

Source: Afer Pilorusso (1983), pp. 68-75.

TABLE 12

FLEET CHARACTERISTICS OF TEN SAMPLED
FOR HIRE AND PRIVATE CARRIERS IN ONTARIO (1986)

Vehicles:	For Hire Carriers Total	For Hire Carriers Owned	For Hire Carriers Leased	Private Carriers Total	Private Carriers Owned	Private Carriers Leased
Total Straight Trucks	18	18	0	148	148	0
Total Straight Trucks with Liquid Tanks	11	11	0	NA	NA	NA
Total Road Tractors	159	143	16	248	248	0
Trailers:						
Total Full Trailers	14	14	0	92	92	0
Total Semi-Trailers	254	202	52			
Total Semi-Trailers With Liquid Tanks	81	78	3	NA	NA	NA
- Trailers < 10 meters	44	42	2	NA	NA	NA
- trailers > 10 meters	37	36	1	NA	NA	NA

Note: Financial characteristics of these same ten firms are examined in Section 3.2 of this report.

Source: Special compilation of Motor Carrier Freight (MCF) and private truck use surveys by Statistics Canada, Transport Division.

TABLE 13

SHIPMENT CHARACTERISTICS OF A SAMPLE OF
SMALL PRIVATE CARRIERS IN ONTARIO
WITH OWNED FLEETS OF LESS THAN 15 UNITS

Carrier	Fleet Units	Total Tonnes Carried, 1986	Number of Shipments 1986	Tonnes/ Shipment	Tonnes/ Truck	Shipments/ Truck
1	8	83,504	2,693	31	10,438	337
2	10	24,819	1,355	18	2,482	136
3	8	17,649	490	36	2,206	61
4	10	15,497	2,706	6	1,550	271
5	12	12,476	584	21	1,040	49
6	5	10,934	1,229	9	2,186	246
7	7	8,238	372	22	1,177	53
8	4	5,059	596	8	1,265	149
9	3	1,816	357	5	605	119
10	4	51	24	2	5	6
11	5	1,433	232	6	287	46
12	10	77	37	2	8	4
TOTAL FOR ALL CASES	86	181,553	10,675	17	2,119	124

Source: Special tabulation of private carrier data, for private carriers with fewer than 15 fleet units, and Ministry of Environment manifest data.

have capabilities for transporting liquid waste, but do not exclusively haul subject waste. Many have solid and liquid transport capabilities. (Appendix 3.)

4.4 Load/Shipment Characteristics

Statistics Canada provided data on fleet sizes for a sample of 12 private carriers with owned fleets of less than fifteen units. This data was supplemented by data from MOE's manifest records. The results are shown in Table 13, which provides an indication of shipment weights, and shipments/fleet unit/year. It is clear from the shipments per truck column that some of these carriers are occupied with hauling subject waste on a regular basis, while others have relatively few subject waste shipments per truck. Such operators must be engaged in hauling other commodities -- either non-subject wastes, or non-waste materials: the economics of the business are such that revenue generating units must be active in some capacity rather than sitting idle. This conclusion is corroborated by the data in Table 10, which indicated that many registered liquid industrial waste carriers hauled only small quantities of liquid waste -- i.e., as a sideline to their other activities. Integration of liquid waste transport activity with other activities is therefore very common amongst carriers.

4.5 Technological Innovation

The Pilorusso study cites the following equipment innovations currently underway in the liquid transportation industry*:

a) small average size of a load from a generator due to better management of waste products.

b) smaller shipment sizes lead to compartmentalized tanks which can carry different waste types in one trip; in effect, increasing the density levels of the waste.

c) a trend towards the use of more tank trailers than straight tank trucks.

*p. 75

5.0 MARKET CONCENTRATION AND MARKET SEGMENTS

This section describes market concentration in the subject waste transportation business, and describes some of the market segments in the industry. The discussion is based on analysis of the top 100 (by tonnage) firms in Ontario, which were discussed previously in Section 4.1.

5.1 Concentration by Size

In Table 14 we set out market share and concentration data on a regional basis. To begin with, the largest three carriers of subject waste in each region account for a disproportionately large share of tonnage and total shipments. For example, in the southwest region, the largest three carriers account for only 11% of all firms but move 51% of total tonnage and account for 46% of total shipments. For the province as a whole, the three largest carriers accounted for 29% of all tonnage and 17% of all shipments.

5.2 Out-of-Province Carriers

Out-of-province firms account for 14% of the province's largest carriers (Table 14). By and large, these firms account for a smaller proportion of total waste shipped in the province than their numbers would suggest. They are generally specialized carriers hauling wastes for specialized treatment in Ontario (e.g. Michigan wastes for incineration at Tricil, or chlorinated wastes for incineration by St. Lawrence Cement in Mississauga) or for reclamation/treatment inside or outside of Ontario (e.g. oils to Breslube; solvents; or liquids destined for "stablex" treatment in Quebec. Several of these firms are affiliated (integrated) with downstream treatment or reclamation operations -- e.g. Speedy Oil with Breslube, and Lubex with Canadian Oil; Tricil's Quebec operations; and American firms such as Environmental Waste Control, Inland Waters Pollution Control and Great Lakes Environmental, which have downstream facilitites in the US.

TABLE 14

MARKET SHARE & CONCENTRATION AMONG THE TOP 100 LIQUID AND HAZARDOUS INDUSTRIAL WASTE CARRIERS IN ONTARIO

Concentration In Each Region by Category:	Southwest	West Central	Central	Southeast	Northern	Ontario: Total
	REGION IN WHICH FIRM IS REGISTERED					
Largest 3 Carriers:						
Firm 1 - Tonnes	120,740	83,504	56,573	10,102	2,644	120,740
# Shipments	7,465	2,693	2,068	875	168	7,465
Firm 2 - Tonnes	32,590	37,021	24,819	8,361	1,463	83,504
# Shipments	1,286	3,280	1,355	375	78	2,693
Firm 3 - Tonnes	31,903	27,507	22,261	8,238	1,377	56,573
# Shipments	1,462	1,888	1,393	372	51	2,068
Top 3 Carriers as % of Region's Total						
- Firms	11%	13%	11%	20%	60%	3%
- Tonnes	51%	58%	48%	48%	72%	29%
- # Shipments	46%	41%	19%	47%	66%	17%
Out of Province Carriers:						
(origin) # of cases	(USA) 7	(USA) 2	0	(4 QUE)5 (1 USA)	0	14
- as % of Region's Total Carriers	25%	17%	0	33%	0	14%
- as % of Region's Wastes Carried	7%	5%	-	25%	-	6%
- as % of Region's Total Shipments	5%	5%	-	21%	-	4%
Largest Integrated "Generators"/Transporters": (see Table 15)						
# of Cases	6*	5	3**	0	1	15
# of Carriers Included In Integrated Totals	9	6	3	0	1	20
- as % of Region's Carriers Included in Integrated Totals	32%	25%	11%	0	20%	20%
- as % of Region's Wastes Carried	53%	63%	8%	-	18%	43%
- as % of Region's Total Shipments	72%	46%	9%	-	11%	39%
Townships:						
# of Townships	0	0	8	6	1	15
- as % of Region's Total Carriers	0	0	32%	40%	20%	15%
- as % of Region's Wastes Carried	0	0	16%	31%	19%	6%
- as % of Region's Total Shipments	0	0	9%	43%	17%	5%

*Includes one "integrated carrier" comprised of three carriers separately registered. The largest is registered in this region, and accounts for 95% of the waste carried by the integrated operation. The other two carriers are registered in West Central and Southeast (originating in Quebec) respectively.

**Includes one firm registered in Southeast region but resident in Quebec, which accounts for more than 1/2 of this integrated carrier's tonnage.

"Northern Region" contains combined data for MOE's Northeastern and Northwestern Regions.

Source: As for Table 9

TABLE 15
LARGE "INTEGRATED" GENERATORS/CARRIERS*, 1986

Company	Totals Consolidated for No. of Generators/Carriers**	Subject Waste Generated (Tonnes)	Subject Waste Carried (Tonnes)	# Shipments	Average Size of Shipment (Tonnes)	%, Waste Carried to Waste Generated
Atlas Steels	1/1	2,948	2,696	77	35	91
Anachemia Solvents	1/1	3,379	6,884	480	14	204
Breslube, Canam Oil etc.	2/2 (1 Cdn., 1 U.S.)	59,696	37,982	3,321	11	64
Canadian Oil Co./Lubex	1/2 (1 Ont., 1 Que.)	3,214	5,251	545	10	163
Canflow	2/1	23,361	10,096	481	21	43
CPW Disposal/Chem-King	1/1	11,641	5,142	1,289	4	44
Dofasco	2/1	31,799	27,507	1,888	15	87
Dow Chemical	1/1	13,416	5,070	595	9	38
Envir Mgt. Corp. London	1/2 (1 U.S., 1 Cdn.)	10,424	37,709	2,329	16	362
Frontier Chem Waste (US)	1/1 (U.S.)	6,395	10,837	846	13	169
Imperial Oil, Esso Petroleum/Chemical	3/1	25,892	9,920	983	10	38
Polysar	1/1	25,652	1,268	184	7	5
Spruce Falls Power & Paper	1/1	2,993	1,377	51	27	46
Tricil	3/3 (2 Ont., 1 Que.)	39,822	127,601	11,502	11	320
Walker Bros./ Woodington Systems	1/1	77,692	83,504	2,693	31	107
Integrated Cases: 15	22/20	338,324	372,844	27,264	14	110

*Matched from the Ministry of Environment's listing of the top 50 generators of subject wastes, and the top 100 carriers of subject waste, from manifest data for 1986.

This provides an indication of the degree of integration. A more detailed analysis would point out further cases - i.e., by analysis of the listing of the next 50 generators, and so on.

Many firms indicated as "generators" are in fact "receivers", i.e., at transfer stations. These firms operate large disposal/treatment facilities and tranship substantial quantities of waste.

**For example, "1/1" indicates that a company has both a generator registration and a carrier certification. "1/2" indicates that a company has one generator registration, and two subsidiaries, affiliates, or related operations with carrier certificates. "2/1" indicates a company with two separately registered generating facilities, and one certified carrier; etc.

5.3 Integrated Carriers

Next, Table 14 considers "integrated carriers" (i.e. firms which, on a consolidated basis, both generate and transport subject wastes; see note to Table 15). As Table 14 indicates, these integrated firms possess a disproportionate market share in the southwest and west central regions. They account for 53% and 63% of total waste carried in each respective region. There is no significant market dominance by integrated firms in the other three regions.

Following up on the activities of the integrated operators, we present in Table 15 a list of the largest integrated firms, and their volumes generated and carried in 1986.

In total these 15 integrated firms generated some 338,324 tonnes and carried 372,844 tonnes; in other words, the firms collectively carried 10% more waste than they generated. In some cases, these firms carried quantities of subject waste well in excess of the amounts they "generated", for example Anachemia Solvents (204%), Environmental Management Corp. (362%) and Tricil (320%). Some of the largest integrated firms are more into the "downstream" waste transport, storage and disposal/treatment/reclamation business. They "generate" wastes at their treatment site, or from transfer stations.

Some of the other carriers are clearly integrated with the "upstream" production processes of their companies. These firms are engaged in hauling their own industrial wastes to a disposal/treatment/reclamation site (e.g. Spruce Falls Power and Paper). (Parenthetically, we include here Polysar and Imperial Oil. Both are generators of liquid waste, and have some capacity for waste transport. However, the nature of these integrated operations is not as clear cut as for others. For example, Polysar has until recently accepted waste from other carriers at its own undercapacity treatment facility; many of the firm's own wastes are brokered rather than handled by itself. These two companies are included here only to illustrate the diversity of the integrated firms' operations.)

The cost and operational considerations which generators and receivers weigh when deciding to operate their own fleets require additional attention.

5.3.1 Upstream Integration

A number of waste carriers are themselves generators of liquid waste. These generators may integrate downstream into carrier activities for cost reasons, or because there are operational imperatives which make hauling their own wastes necessary -- i.e. timeliness of service, or the absence of local carrier capacity. The example provided by three carriers in the top 100 listing who are actually producers in the pulp and paper industry, illustrate a typical generator's transport operations. These three firms are engaged in hauling their own waste from plant to off-site disposal. (One of these firms, Spruce Falls Power and Paper Co., is included as an "integrated" large generator/carrier in Table 15.)

This activity may be regular, or it maybe required only when on-site treatment facilities break down. For example, the James River Marathon plant previously hauled lime mud (classified as a liquid waste) generated by the Kraft pulping process to a local landfill, when its on-site kiln was not in operation. A new process at the plant has reduced the liquid content of the lime mud from 60% to 20%; it is now classified as a solid (based on the slump test) and is not a subject waste. When necessary, it is hauled to a local landfill, in cement trucks owned by the company. Company officials indicate that they use their own vehicles because there are simply no local carriers in their region of the north. The nearest ones are in Thunder Bay -- four hours away. The company is never able to predict when its kiln will be out of operation to notify a commercial carrier.*

All pulp and paper producers in Ontario have some primary effluent treatment facilities on site. Secondary treatment/disposal facilities may or may not be on site, depending on space availability. This seems to be a greater constraint in southern Ontario than the north, as evidenced by a recent article in Pulp and Paper Canada. ** Effluent quantities and treatment requirements depend on the production process utilized at each plant, and the

---

* Lockwood's Directory of the Paper and Allied Trades, 1985; and pers. comm., James River/Marathon officials.

**W.F. Fell and M.T. Reid, "Effluent Treatment Associated with a Modernization Program at Ontario Paper Company", (P & P Canada, 88:5,1987).

primary treatment system. Clarifier systems alone can produce significant quantities of subject liquid waste. The Abitibi/Provincial Papers plant in Georgetown makes 287 shipments/year in contrast with the other plants cited previously.

5.3.2 Downstream Integration

The most common form of integration for carriers of liquid industrial waste is downstream -- that is, with a treatment, reclamation or disposal facility or capability. There are two types of waste stream; these streams dictate cost and fee structures affecting various wastes. They are:

- o wastes which have no other economic use or value;
- o wastes which have value because they are reclaimable, reusable, or recyclable.

Various integrated carriers specialize in various kinds of waste. To illustrate these specializations, it is useful to examine the examples of some of the largest integrated carriers, Tricil, Environmental Management Corporation, and Canam Oil/Breslube.

Tricil Limited is by far the largest carrier (by tonnage) of subject waste in Ontario. The main competitive advantage Tricil has over its competitors is the full-service treatment of waste which is provides its customers -- that is, from plant to final disposal.

Tricil, which is owned by Trimac Limited and C-I-L Inc., has been in the waste management business for over ten years. It operates a fleet of waste transport trucks and solid waste collection and disposal facilities across North America, two Canadian energy-from-waste plants, and liquid industrial waste collection, treatment, destruction and disposal facilities in Ontario and Quebec. Tricil's service activities are carried out from 22 locations in Canada and the United States. Corporate headquarters are in Mississauga.

The liquid Waste Division operates a truck fleet of 80 vehicles out of LaSalle, Quebec, and Sarnia and Mississauga, Ontario. The Mississauga facilities also house pretreatment and transfer operations.

In Sarnia, Tricil's new liquid-injection, high-temperature incinerator system came on stream in October, 1983. The $9 million system replaces the original organic waste incinerator which had operated on the site since the late sixties. The new plant has an annual capacity of 120 million litres of organic waste and 40 million litres of inorganics. Inorganics (dewatered alkaline wastes) are used to remove acid gases from the incinerator exhaust. A fabric filter traps particulate. All the solid process residues are placed in Tricil's secure chemical landfill...Destruction efficiency exceeds 99.99 percent, with a residue by weight of 5 percent.

In Quebec, Tricil has two operations located southwest of Montreal. Tricil (Quebec) Inc., in LaSalle provides waste transportation, transfer and in-plant industrial maintenance...Les Entreprises d'Incineration Industrielle Goodfellow Inc., in Ville Mercier destroys organic wastes by high-temperature incineration. The liquid-injection incinerator, which Tricil has operated since 1973, can handle approximately 38 million litres of liquid waste a year. Incineration conditions are comparable to those at Tricil's Sarnia facility. Waste mixing and blending is performed on-site to prepare a suitable fuel mix.*

In addition to operating its own fleet, Tricil accepts (for a charge) wastes for disposal from other carriers. Some of these wastes are hauled considerable distances. Some are hauled from local generating sites.

The Environmental Management Corporation (EMC) is an example of a carrier which started in a related business (industrial plant cleaning) and diversified into liquid waste transport, and later into limited downstream (transfer station) operations, as the industry grew.**

EMC currently operates a fleet of liquid waste trucks out of London, in addition to its transfer station facility, to which it transports wastes for bulking or pretreatment. EMC operates as a for-hire carrier, charging for

---

* From Chapter X, "Commercial Waste Disposal Services," Hazardous Waste Management Handbook, Fourth Edition (Corpus Information Services, Don Mills, Ontario; c.a. 1986).

** pers. comm., Ted Sorokopas, EMC

disposal; it does not (unlike Breslube -- see below) pay generators for wastes which have potential for reuse, recycling or reclamation. The company has no recycling or disposal capacity on site.

In contrast to Tricil and EMC, the Canam Oil/Breslube conglomerate is in the downstream recycling end of integrated operations. The company operates one of the largest oil recycling operations in North America at Breslau, Ontario. Apparently the company integrated upstream into the carrier business from its refinery operations to ensure a dependable supply for the plant. It currently operates a large fleet of trucks which collects oil throughout Ontario, Quebec and the US. Company officials estimate that Breslube handles 80% of Ontario's waste oil, and 40% of Quebec's*. The remainder of Ontario's waste oil is largely handled by Canadian Oil Co. Ltd.

About 60% of the oil handled at Breslube comes from the United States; the company has a U.S. subsidiary, Speedy Oil, with extensive operations in the northeastern states. A company official indicates that there are no particular problems encountered in crossing the international border with waste oil.

Canam/Breslube's operations are closely linked to the price of crude oil. When the crude price was high, the company paid generators in order to collect from their premises. With the oil price low, as at the present time, Breslube charges for collection services.

Breslube occasionally accepts oil from other carriers, but does not promote this practice. It charges such carriers F.O.B. its facility, so there is no margin for other carriers in such activity. The company indicates that, as an integrated carrier, it can collect, transport and treat the oil more efficiently and cheaply than if it involves other middlemen carriers. Scale and integrated operations are definite advantages to the company in this regard.

---

* pers. comm., Dale Schofield, Canam Oil/Breslube

In the course of its operations, Breslube and its affiliated companies also transport other kinds of subject waste, on an hourly, for-hire basis. Those transport activities are clearly sidelines to the firm's main integrated oil transport and recycling activities. For known, regular shipments, Breslube may charge a fixed fee/gallon, rather than charging on an hourly basis. This may be more attractive to the customer, who does not then have to pay for unpredictable waiting time, etc. This results in a "blended fee" to the customer incorporating both distance and time factors, for example charges per gallon are determined by the following formula:

[(Distance @ $2 per mile) + (2 hours loading @ hourly rate) + 2 hours unloading @ hourly rate) + (1 hour wait at border @ hourly rate)] / size of load (in gallons) = cost per gallon.

Other carriers prefer an hourly rate to a price per gallon. Environmental Management corporation indicates that the latter pricing arrangement may not be advantageous if a truck carries a load of less than its full capacity.)

An American company, Safety-Kleen Corporation, recently acquired Canam Oil/Breslube. Safety-Kleen is a major solvent reclaimer in the U.S. The effects of the takeover on Breslube's operations have not yet (June 1987) become clear.

5.4 Municipal Carriers

Finally, Table 14 examines those carriers in the top 100 who are in fact operated by townships (14) and urban municipalities (1--Metro Toronto). These 15 municipal entities account for only 5% of all shipments, and 6% of all waste tonnages in Ontario -- a disproportionately small percentage considering they constitute 15% of the top carriers. With one exception these townships are located in the central and southeastern regions, where they constitute 32% and 40% of the top carriers in those regions, respectively.

Municipalities in Ontario transport two main liquid wastes: dust suppressant and landfill leachate. The Township of Cramahe (Castleton, Ontario), for

example, hauls one subject waste, "road binder" or "road liquor".* The Township has 250 kilometres of gravel roads which are treated with this liquid during the summer months. Road binder is collected free of charge from Domtar's plant in Trenton. (Domtar in Trenton is the third largest subject waste generator in Ontario; in 1986 almost 4,000 shipments totalling 51,167 tonnes originated from the company.**)

One dump truck is fitted by Cramahe for this purpose with a 2000 gallon tank; in winter the tank is removed and this vehicle reverts to other seasonal duties. The Township thus utilizes its existing capacity and manpower rather than hiring a private carrier for this task. The regional configuration of townships in the top 100 carriers (in central and southeast regions, Table 14) suggests that many of these carriers are engaged in the same activity, sourcing from the Trenton plant.

The other main subject liquid waste carried by townships is landfill leachate, from landfill or treatment sites which they operate. Indeed, six municipal entities (counties, regional municipalities, or urban centres) are on the list of the top 50 subject waste generators in Ontario. The fact that only one of these six generators (Metro Toronto) is on the list of the top 100 carriers is significant -- these large generators clearly contract out disposal to private carriers. Leachate is hauled to the nearest water pollution control plant in the vicinity, for end disposal.

Metro Toronto transports all leachate from its Pickering landfill site (13,440 tonnes) with one 5,000 gallon tank unit, operating daily.***

Metro's labour force is unionized, and objects to any suggestion that this activity be contracted out.*** In addition, it is hard to stipulate carrier specifications and load frequencies because leachate is produced irregularly and must be hauled on an ad hoc basis. Both of these factors contribute to Metro's transporting its own subject liquid waste.

---

* pers. comm. Ms. Peggy Caza, Township of Cramahe office.
** MOE listing of the top 50 generators (by tonnage) in 1986
*** pers.comm., Mr. F.J. Horgan, Municipality of Metro Toronto

The costs to the generator of transporting its own liquid wastes can be higher than if it is contracted out to a transportation specialist. Toronto's experience with solid waste illustrates this point. Metro contracts out about one-half of its solid wastes to private carriers via a tendering procedure. The union resists each time tenders are invited.

Contracts are let for a five year period; new equipment requirements, a letter of credit and/or a performance bond are required of the carrier. Even with these requirements contracting out to private carriers is still about 15% cheaper than internal operations.

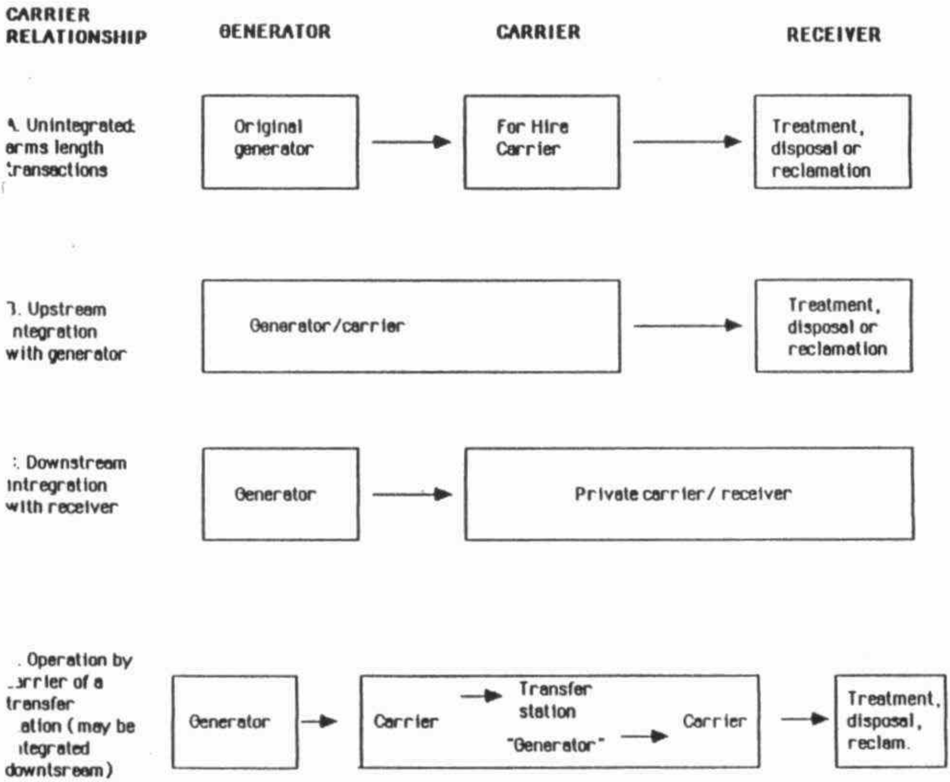
5.5 Market Segments

In the course of this study we have identified a small number of characteristic interrelationships between the generators, carriers and receivers of liquid waste. These various interrelationships are useful in defining the various market segments which make up the waste transport business, and the structure of operations within the segments. This section summarizes the foregoing by describing, by way of models, each type of relationship. Figure 2 illustrates the basic relationships discussed in this section.

By far, the most common relationship (in terms of the total number of certified carriers in Ontario) between carrier, generator and receiver is the unintegrated arrangement illustrated as Case A in Figure 2. This is the simplest form of business arrangement, as all transactions are conducted at arms' length. The carrier merely transports waste from the generator to a receiver identified by the generator, on a for-hire basis.

Case D in Figure 2 illustrates a complication on this basic relationship, where the carrier operates a transfer station for bulking or pretreatment of waste. Because waste is destined initially for a transfer station, the carrier becomes the "receiver" there, and the "generator" of the waste when it is ultimately sent on for disposal or reclamation. This carrier may operate either on a for-hire basis, or receive revenue from the sale of wastes for reclamation/reuse, or both.

FIGURE 2
SEGMENTS IN THE LIQUID WASTE TRANSPORT INDUSTRY



Case B and C in Figure 2 illustrate carrier integration "upstream" (with generator) or "downstream" (with receiver), respectively. These cases have been examined in detail, with case studies, in Section 5.3 above.

In practice waste streams are characterized by various interrelationships between carriers, generators and receivers. Some firms operate under combinations of relationships A through D. The majority of the more than 400 certified carriers in Ontario are characterized by Relationship A. However, as we have noted previously in our discussion of the Table 14, a relatively small number of integrated carriers handle a disproportionately large quantity of the total subject waste transported in Ontario.

6.0 TRANSPORTATION COSTS AND FEES

The cost of operating a truck can vary considerably depending on a number of operational factors. Some of the more important operational factors include:

- o distance of hauls;
- o type of products and required equipment;
- o size of load;
- o special safety and handling problems; and
- o opportunity for back haul.

In the Pilorusso Research Associates study for the Ontario Waste Management Corporation (OWMC), Transportation of Special Wastes in Ontario (1983), the authors indicated that the transportation of liquid industrial waste is extremely competitive with the "dominant selection criteria used by the generators being price" (p.78). That study concentrated on the for-hire sector of carriers, where the carriers did not become involved in reclamation or treatment (as opposed to the private carrier sector). In such a case, for the generators, the removal of waste is an unproductive cost of doing business and therefore they look to the lowest cost of service. Accordingly, the carriers respond to the generators by trying to offer the lowest charge for transportation of liquid industrial waste.

The Pilorusso report goes on to state that transportation fees for liquid industrial waste haulage are based on time rather than volume or distance. The survey revealed a wide range of charges for haulage. Fees varied from $55.00 to $96.50 per hour, with an average of $72.00 per hour in 1983. This wide variation is attributable to differences in equipment being offered as well as local competitive conditions (p.79).

In another study for the OWMC, entitled <u>Transportation -- Primary Information OWMC Facilities Development</u> (1982), the Proctor & Redfern Group of consultants reviewed the haulage costs for wastes and reported a wide variety of factors affecting fees. Aside from normal operating expenses (wages, fuel, maintenance), the report cited additional criteria including (p.14):

- o type of material to be transported;
- o origin and destination of material to be transported;
- o loading and unloading time;
- o frequency of delivery (e.g. weekly, daily);
- o the need to dedicate equipment for the transport of specific substances (e.g. toxic waste); and
- o the quantity of material to be shipped.

The report goes on to state that "haul costs are very sensitive to market conditions, types of materials and quantity transported" (p.14). To support this statement, the report quotes costs in 1982 which are reproduced in Table 16. As we can see, the costs vary depending on the nature of the materials handled. For example, the cost of moving caustic soda is more than twice that charged for fertilizer solutions or sulfuric acid. Similarly, the costs of vehicle rentals vary depending on the material handled; for example, the cost for a vehicle carrying voranol is nearly 50% more than the cost of hiring a vehicle dedicated to moving ammonia.

These studies indicate that there is no simple or direct way to determine how transportation fees for liquid industrial waste are set. Prices for similar products vary widely across the province and are determined by local market conditions. A number of factors -- such as those cited above -- influence costs (and customer prices) in the industry.

TABLE 16

Typical Haul Costs for Materials

Description of Items			Cost
1. Cost per ton - minute of operation (prices vary by type of material and location)			9c. to 13c.
2. Cost per ton - mile of operation (prices vary by type of material and location)			11c. to 18c.
3. Vehicle standing time when loading or unloading of material exceeds one hour			$34.00 /hr.

4. Dedicated vehicle rentals

	Tractor	Trailer
- voranol	$1.72/mi	$1,300.00/month
- ammonia	$1.20/mi	$ 850.00/month
- synthetic resin (2100 cu.ft)	$1.72/mi	$ 825.00/month

5. Sample Material Haul Tariff

Material	From	To	Costs *
Caustic Soda	Sarnia	Toronto	$1.465/100 lbs
Sugar	Oshawa	Leamington	$ .88/100 lbs
Fertilizer solutions	Niagara Falls	Toronto	$ .55/100 lbs
Sulfuric Acid	Niagara Falls	Toronto	$ .65/100 lbs
Crude Oil	Windsor	Toronto	$ 1.34/100 lbs

Notes:

1. Costs based upon minimum loads: from 50,000 lbs. (25 short tons) to 80,000 lbs. (40 short tons)
2. 3% Gasoline surcharge is added to all shipments
3. Tariffs are typically expressed in Imperial Units as of January, 1982.

* Source: Proctor & Redfern Group, Transportation -- Primary Information, for OWMC, (1982).

Two additional factors which are significant in determining fee levels for various wastes, in various locations. First, whether or not the waste has value after treatment (i.e., through reuse, reclamation, or recycling) has a major impact on what some carriers charge (or pay) for waste. Second, the degree of competition and market conditions in the industry -- that is, at a particular location, or for a particular waste -- sets limits on the fees that a carrier can charge.

Since the carriers are not required to file a tariff with the Ontario Highway Transportation Board, each transaction between generator and carrier for the removal of liquid waste is done without creating a public record. Thus, any evidence we could obtain regarding prices is anecdotal, and would be misleading in terms of representing the industry as a whole. Without this detailed information it is not possible to determine such issues as price discrimination or market power.

Having said that, obviously we are unable to determine what volume of liquid waste is "economic" to haul. After all, some materials the generators pay the carriers to remove, while for other materials the carriers will pay the generator for the waste products. In the former case, the "economic" value of the waste to the carrier is zero and thus he has to be paid to remove it. In this situation, the transporter typically charges an hourly rate for the vehicle. One southern Ontario operator cited rates of $69.50/hour for a 2,500 gallon tank, and $93.50/hour for a 5,000 gallon tank. This charge is for transportation only; the carrier charges a direct disposal charge to the generator but this is a "flow through" expense charged directly to the client and comprised of the receiver's exact charge. One northern operator indicated charges for a tank of approximately 3,000 gallons of $75-$80/hour. This operator, however, transports large quantities of non-subject liquid waste for a large local generator at $55/hour. This rate is set by the generator, the only large industrial generator in the region. This waste constitutes 93% of the carrier's total annual transport business. In this instance, the carrier is willing to accept a lower fee because of the large volumes involved.

In other cases, the "economic" value of the waste to the carrier is positive, and he will pay the generator for the opportunity of removing it -- for the carrier can dispose of it at a profit. There are, apparently, cases where integrated carriers haul waste for a generator, to their own transfer-cum-treatment stations; the carriers have developed markets for the subsequently treated (or bulked) waste. In such a case, a carrier has realized revenues from both its upstream and downstream operations. Understandably, these carriers are hesitant to publicize the downstream value of the "wastes". Many generators are, however, actively investigating means to recoup the value of their wastes, or to cut down their waste volumes. As all operators in the waste generator treatment cycle become more sophisticated, such dual revenue situations for carriers will probably not last.

The cost of disposal for any particular potentially recoverable waste may vary widely depending on the degree of its contamination. Near-pure solvents may be purchased outright from generators by carriers. If the same solvent is mixed with another, or if it has a higher solid content, it may still be purchased but at a lower price -- because it is more expensive to treat/reclaim. If it is highly contaminated, it may be a pure waste with no revenue potential; the generator will then contract a carrier on a for-hire basis.

Some wastes are particularly problematic in disposal, and the costs of transportation/disposal are commensurate. Generators may pay $500 per drum for the disposal of chlorinated solvent waste (not, it should be noted, PCB wastes). There is only one site in Canada capable of incinerating chlorinated solvent wastes of greater than 2% concentrations -- the St. Lawrence Cement Company kiln in Mississauga. The Company only receives wastes from one carrier, SCA Chemical Services of Model City, New York State. All Canadian generators must ship their chlorinated wastes to SCA or other receivers in the United States. SCA receives these wastes at a transfer station in New York state, from whence they are trucked to their final incineration sites. Some are trucked to the Mississauga cement kiln, to be incinerated as fuel.

- PCBs (as distinct from chlorinated solvent waste) also pose significant problems. There are no final treatment facilities (i.e. very high temperature incinerators) for pure PCBs in Ontario; they are usually stored on location, or shipped to a storage site. Transport/disposal costs are high. Mineral oils adulterated with PCBs are disposed of for about $100/gallon for small (less than 1,000 gallons) volumes, but the price drops for very large volumes to about $8/gallon. New technology has developed in the USA to enable mobile destruction (incineration) units to destroy PCB-adulterated mineral oils on site. This technology is now in use in Ontario, where over the last two years at least three companies have begun to offer this service -- (PPM, Rondar, and Sunohio). Their competition should reduce charges for incineration by mobile units.

7.0 OTHER FACTORS AFFECTING THE INDUSTRY

7.1 Entry and Exit

There are no published data on the change in the number of firms handling liquid industrial waste. For one thing, many firms handle both liquid and solid wastes, and are thus problematic with respect to any attempt to classify them as carriers of either one or the other. For another, as we indicated earlier, neither Statistics Canada nor the Ontario Ministry of the Environment keep separate tabulations on liquid waste handlers.

We were, however, able to glean some insights into the issues surrounding entry/exit activities from our interviews, which shed some light on the question of movement within the industry. We were able to identify the following as significant barriers for a firm wishing to enter this business:

7.1.1. High capital cost

Liquid industrial waste tankers are specialized units which can run in excess of $150,000 each. This is a substantial hurdle for any operator entering the business, especially if the equipment must be dedicated to one particular waste -- thereby limiting its potential market. Rather than leasing, small operators may be forced to purchase in order to build their equity. At the same time, commercial banks may not be inclined to finance outright purchases of such vehicles because in the event of default the bank could have a difficult task in locating a suitable new buyer for such a specialized truck.

7.1.2. Licenses

Some industry representatives pointed out that the Ontario Ministry of the Environment does not give licenses for liquid waste haulage easily and readily and, thus, potential new entrants to the industry are frightened off by what they perceive to be a long procedure to acquire a license to operate.

7.1.3. Qualified managers and operators

The specialized nature of the industry requires that its managers have a relatively high degree of business and professional expertise in order to make decisions regarding large capital expenditures and marketing. They must also have expertise in the handling and treatment of the wastes their companies haul. Also, truck operators require specialized training under the regulations affecting the shipment of dangerous goods.

The above reasons imply that there have not been many new entrants in recent years.

Regarding the exit of firms, we were told that the liquid industrial waste industry is undergoing rationalization similar to that occurring in the trucking industry in general in response to deregulation. Some smaller firms are being acquired by larger operations for purely competitive reasons, allowing them to engage in integrated operations; some firms of equal size are merging to meet the new competitive situation. The degree to which this rationalization is taking place is not quantifiable, according to industry experts.

7.2 Deregulation and Integration

With the advent of deregulation in transportation in general, industry officials have told us that the industry will see more integration towards "downstream" activities. That is, carriers will attempt to enter the related business of operating disposal sites, with the carriers having the opportunity of charging both for the haulage and disposal of waste. One example in this regard is the highly successful operations of Laidlaw Transportation Inc. which is now actively in the business of providing disposal locations. From that corporation's point of view, it appears to offer a competitive advantage to its generating customers by assuring them of a disposal location, especially since the number of suitable disposal sites in Ontario will not increase at the same rate as the increase in waste volumes, in the face of environmental concerns by local groups (i.e. the "not in my backyard" syndrome). As acceptable sites diminish in number, the

transport carrier who can guarantee disposal will have the upper hand on its competition. Indeed, failure to obtain local approval for treatment or bulking facilities (i.e. a transfer station) has been cited by one northern operator as a constraint on the expansion of local operations.* In that case, local opponents combined to defeat the operator's proposal to develop a transfer station in a local industrial park.

7.3 Influence of Regulatory Factors

Our interviews indicated that regulatory changes increase the cost of operations for a typical firm in the industry in the following ways:

7.3.1 Documentation

The requirements for increased documentation to be supplied to all levels of government, the so-called "paper burden", adds to administrative costs and also can delay shipments before or during transit.

Canam Oil/Breslube, the large waste oil carrier/recycler, estimates that it costs 5 cents per gallon handled to comply with all paperwork, shipment manifests and regulatory requirements, including testing of received wastes. For an integrated firm with Breslube's volume, this results in a $2 million expenditure per year.** Most waste carriers pass on the additional costs of transport and handling to their customers by way of higher fees. Breslube, whose ability to compete with others in the oil products market is dependent upon the world crude oil price, cannot pass additional costs on to its downstream customers when the oil price is low and competition with "new" oil is stiff (as at present).

For unintegrated or basic for-hire carriers, however, higher costs associated with paper burden should not affect their competitive positions, as all carriers are equally affected.

---

* pers. comm., Mr. H. Lindsay, Val Caron, Ont.
** pers. comm., Mr. L.S. Schofield, Canam Oil Services

7.3.2 Training

The new regulations under the Transportation of Dangerous Goods Act require specialized operator training which is borne by the industry. OTA officials estimate that training costs in Ontario alone amount to an additional $2 million burden to the trucking industry as a whole.

7.3.3 Equipment

As new safety and environmental protection features are added to the specifications for tank carriers, the cost of outfitting a firm with the latest approved equipment has added capital costs and associated financing costs. We were unable, however, to find any estimates of the extent of these added costs.

7.3.4 Insurance

The Ministry of the Environment requires all waste management vehicles to have liability insurance coverage of a minimum $1 million. In practice, most operators opt for a greater degree of coverage, if they can afford it.

Many generators insist that their carriers have a higher level of coverage than what the Ministry stipulates. Many of these generators are U.S.-based companies, where this practice originated after cases where they were forced to pay for their carriers' accidents. One large Ontario integrated carrier indicated to us that one of its clients required it to have $5 million in liability insurance; the client company had to waive this rule when this carrier could only obtain $2 million coverage.

The costs of liability insurance have increased enormously in the past two to three years in every type of business. Some carriers indicated to us an increase in premiums in 1986 of 300% with yet higher levels of deductibles. One southern Ontario carrier indicated that his company's premium has risen over the last four years from $8,000 for $5 million coverage, to $100,000 for $2 million coverage.

Insurance for environmental impairment is a new development and outgrowth of Part IX of the Environmental Protection Act, or the "Spills Bill", which requires the carrier to pay for environmental clean-up and damages to third parties.*

To date, Canadian insurance companies have not offered the trucking industry coverage for environmental impairment and, as a result, the individual carriers are, in effect, self-insurers, i.e. they pay for any environmental clean-up resulting from waste products spilling into the environment. Self-insurance is, naturally, the most costly form of insurance and has added to the overall cost of operations.

7.3.5. Generator Requirements

The generator's cradle-to-grave responsibility for wastes has been taken very seriously by leading corporate generators. Beyond the obvious reason of good corporate citizenhood, there are two compelling reasons for this:

- Corporate Liability. Generators are ultimately responsible for how their wastes are disposed of. If problems occur, the Company will have to pay to rectify them.
- Public Relations. A dangerous spill, leak or accident, or inadequate treatment, at any point after the waste leaves the generator's premises can come back to reflect upon the generator.

Above (Section 7.3.4), we cited the fact that generators are beginning to require higher levels of liability insurance coverage by carriers. In addition, some generators conduct their own site inspections of the prospective carrier's facilities and equipment, and assess the carrier's safety procedures. Northern Telecom, for example, is preparing its own criteria for carriers (and disposal sites), and will in future conduct environmental performance audits to develop an approved list

---

* For a discussion of the impact of the "Spills Bill" on truckers, see <u>Ontario Trucking Today</u>, "Remember the Spills Bill?", May/June, 1987.

of carriers for the firm's various locations. Carriers' insurance coverage and assets will also be examined.*

Generators are also actively investigating means to reduce the volume of their waste which must be moved off their premises. This trend has dual purposes -- to reduce the quantity of waste which carriers must transport, and to recoup value from the waste by internal recycling.

7.4 Factors Affecting Technological Change

The transportation of liquid industrial waste is undergoing some technological change in terms of the type of equipment used, and the operation of transfer stations to bulk or treat wastes. One of the most interesting technological developments is the introduction of fibreglass tanks, which can haul a wider variety of wastes than either mild carbon steel or stainless steel tanks. Fibreglass is not corroded by wastes which would corrode even stainless steel.

In discussions with industry experts, three main forces were cited as pushing carriers to introduce new technology. They are:

7.4.1. Market pressures

The economic opportunities for specific liquid industrial waste products are constantly shifting. A waste product once considered to have no economic value can, in a relatively short time, become a useful commodity with a market value which results in a new segment of the industry. One such example is "pickle liquor" (a waste product in steel making) which steel makers formerly paid to dispose of. Recently, an economic use has been found for this waste and a new segment of the waste haulage industry has emerged, requiring specialized carrying and handling/treatment techniques.

---

*pers. comm., Mr. T.W. Sorokopas, Environmental Management Corp., and Mr. D.T. MacLeod, Northern Telecom.

7.4.2. New standards for safety

As federal and provincial authorities pass legislation upgrading safety requirements, the industry is constantly looking for new and better equipment to meet these standards without adding to the cost of operations. Cost containment is a driving force in developing new technology to meet these standards.

7.4.3. Environmental protection

With the introduction of legislation, such as the "Spills Bill" which places a heavy financial burden on the carrier for environmental clean-up, the industry is naturally looking to new technology to minimize the risks in transporting waste products.

Glossary of Terms

For-hire vehicles

Transportation vehicles hired by a waste generator to transport waste products to a transfer station or disposal site.

Private Carriers

Transportation vehicles owned by a generator and used to transport that generator's waste products to a transfer station or disposal site.

Bulking

The storing of the same waste product from two or more generators in a transfer station until such times as the quantity stored is sufficiently large to make it economically efficient to transport to a disposal site.

Up-stream and Down-stream operations

Up-stream operations refer to the generation of waste products in an industrial activity. Down-stream operations refer to the disposal of waste products by either a carrier or disposal operator.

Selected Bibliography

Consultant Reports

A. Cubkugil, Recent Trends in Transborder Trucking Between Ontario and the U.S. for Ontario Ministry of Transportation and Communications (1986).

Pilorusso Research Associates Inc., Transportation of Special Wastes in Ontario, for the Ontario Waste Management Corporation, (1983).

Proctor & Redfern Limited, Transportation-Primary Information OWMC Facilities Development Process for Ontario Waste Management Corporation (1982).

Proctor & Redfern Limited, Waste Quantities Study for the Ontario Waste Management Corporation (1982).

University of Toronto/York University Joint Program in Transportation, Regulatory Policy and Data Needs in Commercial Trucking Industry for Ontario Ministry of Transportation and Communications Truck Office (1985).

Journal Articles and Other Related Private Publications

Ontario Trucking Today, "National Safety Code Moves Ahead with OTA Push" May/June 1987.

Pulp & Paper Canada, "Effluent Treatment Associated with a Modernization Program at Ontario Paper Company", 88:5 (1987)

Waste Age, various issues

Corpus Information Services, Hazardous Waste Management Handbook, Fourth Edition, (1986)

Government Publications

Ontario Ministry of the Environment, Handle with Care: An Outline of the Responsibilities of Generators, Carriers and Receivers of Liquid Industrial and Hazardous Waste, 1985.

Ontario Ministry of the Environment, Driver Training Guideline: An Outline of the Essential Components of Training Programs for Drivers of Liquid Industrial and Hazardous Waste Transportation Vehicles, August 1986.

Ontario Ministry of the Environment, Registration Guidance Manual for Generators of Liquid Industrial and Hazardous Waste, July, 1985.

Ontario Regulation 309: General - Waste Management. revised Regulations of Ontario, 1980 as amended to O.Reg. 464/85 under the Environmental Protection Act, November 1985.

APPENDIX 1

SHIPMENT MANIFEST

Ministry of the Environment / Ministère de l'Environnement
Ontario

MANIFEST / *MANIFESTE*

"Regulation 309, R.R.O. 1980, Form 1." "*Règlement 309, R.R.O. de 1980, formule 1.*"

(Instructions on Reverse) / *(Instructions au verso)*

A Generator (Consignor) / Producteur (Expéditeur)

Generator Registration No. / Nº d'inscription du producteur (Provincial No.) / (Nº provincial)

Company Name / Nom de la compagnie

Head Office Address / Adresse du siège social — City / Ville — Prov. — Postal Code / Code postal

Shipping Site Address / Adresse du lieu d'expédition

City / Ville — Prov. — Postal Code / Code postal

Intended Receiver (Consignee) / Réceptionnaire (Destinataire) prévu — Receiver No. / Nº du réceptionnaire (Provincial No.) / (Nº provincial)

Receiving Site Address / Adresse du lieu de réception

City / Ville — Prov. — Postal Code / Code postal

B Carrier / Transporteur

Certificate of Approval No. / Nº de certificat d'approbation (Provincial No.) / (Nº provincial)

Company Name / Nom de la compagnie

Address / Adresse

City / Ville — Prov. — Postal Code / Code postal

Registration / Enregistrement	Licence Plate No. / Nº de plaque d'immatriculation	Prov. / Prov.
Vehicle / Véhicule		
Trailer # 1 / 1re remorque		
Trailer # 2 / 2e remorque		

Point of entry / Point d'entrée — Point of exit / Point de sortie

Carrier Certification: I declare that the information contained in Section B is correct and complete. / Déclaration du transporteur: J'atteste que les renseignements inscrits à la partie B sont exacts et complets.

Name of Driver (print) / Nom du conducteur (lettres moulées) — Tel. No. (Area Code) / Nº de tél. (ind. rég.) ( )

Signature — Day / Jour Month / Mois Yr. / An

Physical State (Solid, Liquid, Gas) / État physique (Solide, liquide, gaz)	Shipping Name of Waste / Appellation réglementaire des déchets transportés	Waste Identification No. / Nº d'identification des déchets: Provincial	TDGA / LTMD	Quantity Shipped / Quantité expédiée	Units L/kg / Unités	Classification	Packing Group / Groupe d'emballage	Containers: Number / Nombre	Containers: Type	Packaging Comments

Special Handling Emergency Instructions / Instructions spéciales de manutention en cas d'urgence — Attached / Annexées ☐ — Below / Ci-dessous ☐

Date Shipped / Date d'expédition: Day / Jour Mon. / Mois Yr. / An — Time / Heure ☐ A.M. ☐ P.M.

Scheduled Arrival Date / Date d'arrivée prévue: Day / Jour Mon. / Mois Yr. / An

Generator (Consignor) Certification: I declare that the information contained in Section A is correct and complete. / Déclaration du producteur (expéditeur): J'atteste que les renseignements inscrits à la partie A sont exacts et complets.

Name of Authorized Person (print) / Nom de la personne autorisée (lettres moulées) — Signature — Tel. No. (Area Code) / Nº de tél. (ind. rég.) ( )

Conforms to Transportation of Dangerous Goods Regulations under the Act, Chapter 36, SC 1980 / Conforme au règlement sur le transport des marchandises dangereuses en application de la loi, chapitre 36, SC 1980

Circulation No. (Quebec only) / Nº de circulation (réservé au Québec) — Other Manifest Number(s) / Autre(s) numéro(s) de manifeste(s)

C Receiver (Consignee) / Réceptionnaire (Destinataire)

Receiver No. / Nº du réceptionnaire (Provincial No.) / (Nº provincial)

Company Name / Nom de la compagnie

Address / Adresse

City / Ville — Prov. — Postal Code / Code postal

Receiving Site Address / Adresse du lieu de réception

City / Ville — Prov. — Postal Code / Code postal

Date Received / Date de réception: Day / Jour Mon. / Mois Yr. / An — Time / Heure ☐ A.M. ☐ P.M.

Quantity Received / Quantité reçue	Units L/kg / Unités	Identify Any Shipment Discrepancy Problems. Attach addendum if necessary	Handling Code / Code de traitement	Denaturement: Packaging / Contenant Yes / Oui No / Non	Denaturement: Vehicle / Véhicule Yes / Oui No / Non

If handling code "other", specify / Si le code de manutention est "autre", préciser

If waste is to be transferred specify intended ultimate receiver name / Si les déchets doivent être transférés préciser le nom du destinataire — Receiver No. (Provincial No.) / Nº du réceptionnaire (Nº provincial)

Address / Adresse — City / Ville — Prov.

Receiver (Consignee) Certification: I certify that the information contained in Section C is correct and complete. / Déclaration du réceptionnaire (destinataire): J'atteste que les renseignements inscrits à la partie C sont exacts et complets.

Name of Authorized Person (print) / Nom de la personne autorisée (lettres moulées)

Signature — Tel. No. (Area Code) / Nº de tél. (ind. rég.) ( )

12708 (7/85)

APPENDIX 2

SUBJECT WASTE CLASSIFICATION

ONTARIO MINISTRY OF THE ENVIRONMENT

WASTE CLASSES, JANUARY, 1986

INORGANIC WASTES

		EXAMPLES
Acid Solutions		
111	Spent pickle liquor	Acid solutions of sulphuric and hydrochloric acids containing ferrous salts from steel pickling
112	Acid solutions, sludges and residues containing heavy metals	Solutions of sulphuric, hydrochloric and nitric acids containing copper, nickel, chromium, zinc, cadmium, tin, lead, or other heavy metals; chromic acid waste; acidic emission control sludges from secondary lead smelting
113	Acid solutions, sludges and residues containing other metals and non-metals	Solutions of sulphuric, hydrochloric, hydrofluoric and nitric acids containing sodium, potassium, calcium, magnesium or aluminum; equipment cleaning acids; cation regenerant; reactor acid washes; catalyst acid and acid washes.
114	Other inorganic acid wastes	Off-specification acids; by-product hydrochloric acid; dilute acid solutions; acid test residues.
Alkaline Solutions		
121	Alkaline solutions, sludges and residues containing heavy metals	Metal finishing wastes; plating baths; spent solutions containing metals such as copper, zinc, tin, cadmium; case hardening sludges; spent cyanide destruction residues; dewatered solids from metal and cyanide finishing wastes and cyanide destruction.
122	Alkaline solutions, sludges and residues containing other metals and non-metals, not containing cyanides	Alkaline solutions from aluminum surface coating and etching; alkali cleaner wastes; waste lime sludges and slurries; anion regenerants.
123	Alkaline phosphates	Bonderizing wastes; zinc phosphates; ferrous phosphates; phosphate cleaners.
Aqueous Salts		
131	Neutralized solutions, sludges and residues containing heavy metals	Metal finishing waste treatment sludges containing copper, nickel, chromium, zinc or cadmium; neutral salt bath sludges and washes; lime sludge from metal finishing waste treatment; dewatered solids from these processes.
132	Neutralized solutions, sludges and residues containing other metals	Aluminum surface coating treatment sludges; alum and gypsum sludges.
133	Brines, chlor-alkali sludges and residues	Waste brines from chlor-alkali plants; neutralized hydrochloric acid; brine treatment sludges; dewatered solids from brine treatment.
134	Wastes containing sulphides	Petroleum aqueous refinery condensates.
135	Wastes containing other reactive anions	Wastes containing chlorates; hypochlorite; bromate or thiosulphate.
Miscellaneous Inorganic Wastes and Mixed Wastes		
141	Inorganic wastes from pigment manufacturing	Wastewaters and sludges from the production of chrome yellow, molybdate orange, zinc yellow, chrome green and iron pigments; dewatered solids from these sources.
142	Primary lead, zinc and copper smelting wastes	Slurries, sludges and surface impoundment solids; treatment plant sludges; anode slimes and leachate residues; dewatered solids from these sources.
143	Residues from steel making	Emission control sludges and dusts; precipitator residues from steel plants; dewatered solids from these sources.
144	Liquid tannery waste sludges	Lime waste mixtures; chrome tan liquors; dehairing solutions and sludges.
145	Wastes from the use of paints, pigments and coatings	Paint spray booth sludges and wastes; paper coating wastes; ink sludges; paint sludges.
146	Other specified inorganic sludges, slurries or solids	Flue gas scrubber wastes; wet fly ash; dust collector wastes; metal dust and abrasives wastes; foundry sands; mud sediment and water; tank bottoms from waste storage tanks that contained mixed inorganic wastes; heavy sludges from waste screening/filtration at transfer/processing sites not otherwise specified in this table.
147	Chemical fertilizer wastes	Solutions, sludges and residues containing ammonia, urea, nitrates and phosphates from nitrogen fertilizer plants.
148	Miscellaneous waste inorganic chemicals	Waste inorganic chemicals including laboratory, surplus or off-specification chemicals, that are not otherwise specified in this table.
149	Landfill leachate	Surface run-off and leachate collected from landfill sites.
150	Inert inorganic wastes	Sand and water from catch basins at car washes; slurries from the polishing and cutting of marble.

ORGANIC WASTES

Non-halogenated Spent Solvents		
211	Aromatic solvents and residues	Benzene, toluene, xylene solvents and residues.
212	Aliphatic solvents and residues	Acetone, methylethylketone and residues, alcohols, cyclohexane and residues.
213	Petroleum distillates	Varsol, white spirits and petroleum distillates, thinners.
Fuels		
221	Light fuels	Gasoline, kerosene, diesel, tank drainings/washings/bottoms, spill clean-up residues.
222	Heavy fuels	Bunker, asphalts, tank drainings/washings/bottoms, spill clean-up residues.

(over)

231	Latex wastes	Waste latexes, latex crumb and residues.
232	Polymeric resins	Polyester, epoxy, urethane, phenolic resins, intermediates and solvent mixtures
233	Other polymeric wastes	Off-specification materials, discarded materials from reactors
Halogenated Organic Wastes		
241	Halogenated solvents and residues	Spent halogenated solvents and residues such as perchloroethylene, trichloroethylene and carbon tetrachloride (dry cleaning solvents); halogenated still bottoms; residues and catalysts from halogenated hydrocarbon manufacturing or recycling processes.
242	Halogenated pesticides and herbicides	2,4-D, 2,4,5-T wastes, chlordane, mirex, silvex, pesticide solutions and residues.
243	Polychlorinated biphenyls (PCB)	Askarel liquids such as Aroclor, Pydraul, Pyranol, Therminols, Inerteen, and other PCB contaminated materials.
Oily Wastes		
251	Waste oils/sludges (petroleum based)	Oil/water separator sludge; dissolved air flotation skimming; heavy oil tank drainage; slop oil and emulsions.
252	Waste crankcase oils and lubricants	Collected service station waste oils; industrial lubricants; bulk waste oils.
253	Emulsified oils	Soluble oils; waste cutting oils; machine oils.
254	Oily water/waste oil from waste transfer/processing sites	Waste oil and oily water limited to classes 251, 252 and 253 that have been bulked/blended/processed at a waste transfer/processing site.
Miscellaneous Organic Wastes and Mixed Wastes		
261	Pharmaceuticals	Pharmaceutical and veterinary pharmaceutical wastes other than biologicals and vaccines; solid residues and liquids from veterinary arsenical compounds.
262	Detergents and soaps	Laundry wastes.
263	Miscellaneous waste organic chemicals	Waste organic chemicals including laboratory surplus or off-specification chemicals that are not otherwise specified in this table.
264	Photoprocessing wastes	Photochemical solutions, washes and sludges.
265	Graphic arts wastes	Adhesives; glues; miscellaneous washes; etch solutions.
266	Phenolic waste streams	Cresylic acid; caustic phenolates; phenolic oils; creosote.
267	Organic acids	Carboxylic or fatty acids; formic, acetic, propionic acid wastes; sulphamic and other organic acids that may be amenable to incineration.
268	Amines	Waste ethanolamines; urea; tolidene; Flexzone waste; Monex waste.
269	Organic non-halogenated pesticide and herbicide wastes	Organophosphorus chemical wastes; arsenicals; wastes from MSMA and cacodylic acid.
270	Other specified organic sludges, slurries and solids	Tank bottoms from mixed organic waste bulking tanks at waste transfer sites; mixed sludges from waste screening/filtration at waste transfer/processing sites not otherwise specified in this table.
Processed Organic Wastes from Transfer Stations		
281	Non-halogenated rich organics	Blended/bulked non-halogenated solvents, oils and other rich organics prepared at transfer/processing sites for incineration.
282	Non-halogenated lean organics	Blended/bulked aqueous wastes prepared at transfer/processing sites for incineration and contaminated with non-halogenated solvents, non-halogenated oils and other non-halogenated organics.
Plant and Animal Wastes		
311	Organic tannery wastes	Fleshings; trimmings; vegetable tan liquors; Bate solutions.
312	Pathological wastes	Human anatomical waste; infected animal carcasses; other non-anatomical waste infected with communicable diseases; biologicals and vaccines.

OTHER WASTES

Explosive Manufacturing Wastes		
321	Wastes from the manufacture of explosives and detonation products	Wastewater treatment sludges; spent carbon; red/pink waters from TNT manufacturing; residues from lead base initiating compounds.
Compressed Gases		
331	Waste compressed gases.	Methane (natural gas); [illegible]

APPENDIX 3

FLEET CHARACTERISTICS OF A SAMPLE OF CERTIFIED CARRIERS

(44 certified waste carriers selected from MOE carrier certification records; See Section 4.2 of the Report)

FLEET CHARACTERISTICS OF A SAMPLE OF 44 CERTIFIED CARRIERS, BY M.O.E. REGION

	SOUTHWEST				WEST CENTRAL				CENTRAL			
Carrier	Liquid Waste as % of Total Waste Carried	#	Type of Equipment/ Vehicles	Firm's Liquid Capacity (Gal)	Liquid Waste as % of Total Waste Carried	#	Type of Equipment/ Vehicles	Firm's Liquid Capacity (Gal)	Liquid Waste as % of Total Waste Carried	#	Type of Equipment/ Vehicles	Firm's Liquid Capacity (Gal)
1	100%	3	vac. trucks	6,000	100%	3	tanker trucks	4,500	100%	1	truck	2,620
					* 357 manifested shipments totalling 1,816 tonnes in 1986. Average = 5 tonnes.							
2	10%	5	self-pumping trucks	7,500	60%	4	tankers	20,000	100%	1	truck	250
3	10%	2	vac. trucks	5,000	100%	1	vac. unit	2,000	100%	2	vac. trucks	4,000
4	30%	3	vac. trucks	6,000	40%	2	vac. trucks	6,400	-	3	pump trucks	6,900
5	100%	1	tpt. truck	8,000	100%	2	tankers	8,800	30%	21	vac. trucks, supersuckers or guzzlers	20-40 cu.yds. or 2-3,000 gal.
					* 291 manifested shipments totalling 7,160 tonnes in 1986. Average 25 tonnes.				* 396 manifested shipments totalling 3,344 tonnes in 1986. Average = 8 tonnes.			
6	100%	1	tank truck	1,900	90%	11 12 8	tank/ vac. trailers box/ flatbed trailers @ 76 drums each dumps for solid wastes	55,000	-	3 1	vans for return of drummed liquid waste tractor trailer	? ?
7	50%	3 1	vac/trucks trailers trailer for drums	?	-	1	lugger for solids	-	-	3	trucks for solids	-
	* 481 manifested shipments totalling 10,096 tonnes in 1986. Average = 21 tonnes.											
8	10%	3	vac trucks	?	-	30	dumps for solid wastes	-	-	small fleet for solid hazardous wastes	?	?
9	50%	5 3 +	vac trucks/ bulk tankers trailers for drums large fleet for solid waste	? ?					-	small fleet for for solid wastes		?
10	-	33	bulk hoppers for solid wastes	-								

Source: Carrier certification files, Ontario Ministry of the Environment. Sample selected randomly by L. Mathews of MOE.

FLEET CHARACTERISTICS OF A SAMPLE OF 44 CERTIFIED CARRIERS, BY M.O.E. REGION

SOUTHEAST				NORTHERN			
Liquid Waste as % of Total Waste Carried	#	Type of Equipment/ Vehicles	Firm's Liquid Capacity (Gal)	Liquid Waste as % of Total Waste Carried	#	Type of Equipment/ Vehicles	Firm's Liquid Capacity (Gal)
100%	3	vac. trucks	8,000	40%	5	trucks/vans for drummed waste	?
-	1	vac. truck	4,200	20%	2 2	tank trucks trucks	4,000 ?
100%	3	trucks	5,900	100%	3	trucks	18,000
100%	12	trucks for 1-6 45. drums	?	100%	2	vac. trucks	2,900
80%	1	straight truck for drummed liquid	?	50%	4	vac. trucks (2 for sewage)	8,000
-	1	16 yd. tandem for solid waste	-	30%	1	3/4 ton truck for drums	?
-	-	fleet mostly for solids; some tanks for leachate * 372 manifested shipments totalling 8,238 tonnes in 1986. Average = 22 tonnes.	-	75%	1	1-ton truck for drums	?
				100%	3 1 1	tankers 5 ton van for drums 1/2 ton van for drums	42,000 30 drums ?
				30%	5	5 ton dumps for solid waste, sludge * 41 manifested shipments totalling 1,045 tonnes in 1986. Average = 25 tonnes.	
				-	14	excavators, loaders, earthmovers for spill cleanups.	-

The Effects of Forestry Operations
Upon the Environment of Ontario.

by
Julian A. Dunster.
Forestry Consultant.
The Federation of Ontario Naturalists

A large amount of detailed information about specific aspects of forestry exists. However, it is increasingly apparent that the effects of forestry operations upon the environment of Ontario are complex, and the linkages between the physical, economic and socio-cultural environment are not being clearly identified, or are poorly understood. The detail available on specific environmental effects is variable in quality, quantity, and relevance to the present day situation.

As a biologically intricate ecosystem, forests are subject to complex short and long-term cycles. The scope of the effects and the linkages between different parts of the environment, such as micro-climate, hydrology and vegetation, are not fully known, and the cumulative effects of disturbances on the future viability of the environment have been barely explored. The technical information available about the environmental effects of forestry in general, and in Ontario specifically, is extremely disparate.

As a result, decision makers, resource managers or the public, are often forced to choose from one of several options, many of which are based on incomplete technical information. A weak synthesis creates uncertainties and information gaps in the base of knowledge. For example, there are large information gaps about the linkages between environmental, socio-economic and cultural factors which influence the future viability of forestry operations in Ontario.

Several factors limit our understanding of the environmental effects of forestry operations. Firstly, much of the available literature is ecosystem specific, and does not match the Ontario situation. Secondly, the level of technical detail varies considerably. Thirdly, there is no existing comprehensive review and integration of the knowledge available and applicable to Ontario.

These deficiencies in availability and transferability of technical information limit our ability to predict what the environmental effects of forestry operations might be; how they are linked to other parts of the environment, their severity, short and long-term effects, and how they might either be avoided in the first place, or mitigated where necessary. There are several techniques available to attempt a resolution of this problem. Two of the more recent innovations include "State of the Environment" reports, recent examples of the which are the State

of the Environment Report for Canada (Environment Canada 1986), and the State of the Environment Report for the Regional Municipality of Waterloo (Elkin, Couture and Palmer 1986), and environmental audits.

An environmental audit reviews the current situation in comparison to what has been and what is predicted. A 'State of the Environment' report gathers together information on a spectrum of environmental issues. Trends are analysed and evaluated and a framework is then developed to demonstrate the interdisciplinary linkages needed to more fully understand how causative actions will lead to desirable or undesirable effects. From this framework, management and planning strategies can be implemented and momitored in an iterative learning process.

It is anticipated that the product of the research underway will help to:

1. - provide the Ministry of the Environment and the Federation of Ontario Naturalists with recommendations about the environmental effects of forestry operations which require short and long-term attention, including possible solutions and options.

2. - reduce the number of information gaps in the present knowledge and understanding of the environmental effects of forestry operations in Ontario.

It will also provide an analysis of the strengths and weaknesses of the existing knowledge and will allow future research to fill in some of the information gaps identified.

Elkin, T.J., Couture, S., and Palmer, J. 1986. State of the Environment Report, Regional Municipality of Waterloo. University of Waterloo : School of Urban and Regional Planning.

Environment Canada. 1986. State of the Environment Report for Canada. Ottawa : Environment Canada.

BIOTECHNOLOGY POLICY DEVELOPMENT

Canadian Environmental Law Research Foundation

For purposes of this work, BIOTECHNOLOGY refers to the enabling technologies of recombinant DNA and cell fusion.

A study was carried out by the Canadian Environmental Law Research Foundation to:

a. obtain a tentative consensus and, possibly, a priority listing about environmental effects and policy issues,

b. provide suggestions for the development of policies to regulate and ensure the safety of biotechnology activities,

c. comment on the extent to which existing legislation administered by the Ontario Ministry of the Environment could be used to regulate the biotechnology industry.

The study involved an extensive literature review, two workshops (one on the biological effects and implications of biotechnology and one on policy and regulatory issues) and interviews with workers in this field.

The major recommendations in the report are as follows:

1. THE ONTARIO MINISTRY OF THE ENVIRONMENT AND THE ONTARIO GOVERNMENT SHOULD NOT WAIT FOR THE CANADIAN GOVERNMENT TO IMPLEMENT ITS APPROACH TO REGULATION AND INSTEAD IT SHOULD ESTABLISH THEIR OWN REGULATORY OBJECTIVES, POLICIES AND LEGISLATIVE AND REGULATORY MECHANISMS.

2. THE ONTARIO MINISTRY OF THE ENVIRONMENT SHOULD DO WHAT IT CAN TO LEND A SENSE OF URGENCY TO THE FEDERAL PROCESS SINCE REGULATION WILL ALMOST INEVITABLY BE A SHARED FEDERAL-PROVINCIAL RESPONSIBILITY.

3. EXISTING LEGISLATION MUST BE AMENDED TO PROVIDE A SOUND LEGISLATIVE BASIS FOR REGULATION.

4. AT THIS TIME, THE MINISTRY OF THE ENVIRONMENT SHOULD REQUIRE THAT ALL EXPERIMENTAL RELEASES OF MODERN GENETICALLY ENGINEERED ORGANISMS RECEIVE APPROVALS FROM THE MINISTRY OF THE ENVIRONMENT, REGARDLESS OF THE REGULATORY AGENCY WHICH MAY EVENTUALLY GOVERN COMMERCIAL APPLICATIONS FLOWING FROM SUCH A TEST.

5. THE MINISTRY SHOULD MOVE QUICKLY TO DEVELOP A DISCUSSION PAPER SETTING OUT THE WAY IN WHICH THE MINISTRY WILL ENSURE PROTECTION OF THE ONTARIO ENVIRONMENT AND CIRCULATE THIS DOCUMENT FOR PUBLIC DISCUSSION.

6. UNTIL LEGISLATIVE AMENDMENTS ARE ADOPTED, THE MINISTRY OF THE ENVIRONMENT SHOULD USE THE ENVIRONMENT ASSESSMENT ACT AS THE LEGISLATIVE BASIS FOR APPROVING APPLICATIONS FOR EXPERIMENTAL FIELD TESTS IN ONTARIO.

1987 Technology Transfer Conference,
Co-ordination Plus Inc., Conference Secretariat
65 Queen Street West, Suite 2102
Toronto, Ontario M5H 2M8
Phone (416) 862-9067